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EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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The gentleman appointed will be required to devote the whole of his time to his duties, and will not be allowed to engage in private practice. Canvassing, either directly or indirectly, will be regarded as a disqualification, but printed copies of testimonials may be forwarded to the members of the Selection Committee, a list of whom, together with a definition of duties applicable to the position, can be obtained on application to the undersigned.

The applications stating age, qualifications and experience, accompanied by copies of not more than three recent testimonials, and endorsed "Borough Surveyor and Water Engineer," to be sent to the undersigned not later than 12 o'clock at noon on Saturday, the 12th day of January, 1918.

Original testimonials must not be sent, and, if sent, will not be returned.

By Order,
LEWIS BEARD,
Town Clerk.
Town Hall, Blackburn,
7th December, 1917. J 735

Wanted, a Thoroughly Competent, practical Mechanical and Electrical ENGINEER as Chief, capable of supervising establishment of large works devoted to engineering and the chemical industry. Must thoroughly understand management of men. Experience in electro-chemistry desirable. Remuneration no consideration if first-class man.—Address, J 667, Offices of Engineering.

Wanted, Immediately, Prime Cost and Estimating CLERK, thoroughly experienced in General Engineering work; reliable and quick. No one employed on Government work will be engaged.—State full particulars of experience, age, whether ineligible and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 615.

Cost Clerk Wanted, for urgent Government work (Yorkshire district). Must be thoroughly experienced in analysis of weights and accounts, also on-cost charges, in connection with foundry and machine shops. Progressive position to steady, energetic man, capable of assisting the organising and working up of up-to-date cost systems. State age, experience and salary required. No person already employed on Government work will be engaged.—Applicants must apply to their nearest EMPLOYMENT EXCHANGE, mentioning Engineering and J 739.

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Assistant Metallurgical CHEMIST REQUIRED, for laboratory of large engineering works (controlled establishment) in Lincolnshire. Experience in analysis of iron, steel, alloys, &c., desirable. No person already engaged on Government work will be considered. Particulars stating salary required, &c.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4353. J 773

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Assistant Locomotive SUPERINTENDENTS REQUIRED for the Nigerian Government Railway for two tours with possible extension. Salary £300-£10-£350 and a war bonus in certain circumstances. Free quarters and first-class passages. Liberal leave in England on full salary.—Candidates, age between 25 and 45, with experience in running sheds and drawing office, should apply at once (by letter) to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1. Men engaged on Government work or eligible for military service need not apply. J 799

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1918,

Appoint Three Natives OF INDIA, if found qualified, as ASSISTANT ENGINEERS in the Indian Public Works and State Railway Departments.

Candidates must be eligible under Clause 5 of the Regulations, and save as provided in Clause 3 of the Regulations, must be not less than 21 and not more than 24 years of age on 1st July, 1918. They must either have obtained one of the certain recognised University degrees or other distinctions in Engineering, or have passed the Associate Membership Examination of the Institution of Civil Engineers.

Applications must reach the India Office by 31st March, 1918. Printed forms, together with information regarding the conditions of appointment, may be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W.1.

India Office, London.
5th December, 1917. J 801

Wanted, a Good Accountant, to take charge of works' accounts of a large manufacturing firm. Experience of estimating and specifications necessary. No one residing more than ten miles away or already engaged on Government work will be engaged. — Address, "WORKS ACCOUNTANT," care of Chas. Tayler and Co., 30, Fleet Street, London, E.C. 4. J 798

Night Superintendent REQUIRED by firm of aeronautical engine manufacturers in London district. Must be qualified engineer and have held similar position before. Good prospects. Position a permanency. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 4178. J 690

Civil Engineer's Assistant REQUIRED. Good Draughtsman and used to Ferro Concrete work. No one resident more than 10 miles away or already engaged on Government work need apply.—Write Z.A. 681, care Deacon's, Leadenhall Street, E.C. 3. J 777

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Salary £600, per annum, two months leave on half-pay after 12 months' service, increased to four months if returning to Colony; free passage and quarters. Selected candidate to pass a strict medical examination.—Apply by letter, giving full particulars, to Messrs. COODE, MATTHEWS, FITZMAURICE & WILSON, 9, Victoria Street, Westminster, S.W. 1. No person eligible for military service need apply. J 779

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Wanted, as Soon as Possible, a Smart, Up-to-date Jig and Tool DESIGNER, capable of checking tool drawings, in large works in West London. Must have had good all-round experience and be a good mathematician. Only those not already on Government work and residing within a ten-mile radius need apply, stating age, salary and experience.—Address, J 740, Offices of Engineering.

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Wanted, in a London Technical College, a practical ENGINEER (College trained), to assist in the teaching, day and evening work; one with teaching experience preferred. Commencing salary £150 per annum.—Address, C.E., 5, St. George's Terrace, Regent's Park, N.W., giving full particulars of training and experience, with copies of three testimonials. J 709

Aeronautical Engineers, London, N.W., have VACANCIES for DRAUGHTSMEN preferably, but not necessarily with previous experience of aircraft work. Apply by letter, stating age, salary, particulars of experience and when disengaged. No one need apply who is engaged on Government work or who resides more than ten miles away.—BOX B 514, Sells, Ltd., Fleet Street, E.C. 4. H 905

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Only those having previous first-class experience need apply, and no person already on Government work will be engaged.

Apply, in first instance, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4205, and stating particulars of experience, age and salary expected. J 690

Draughtsman for Tool and Jig work, also for planning and production departments, urgently REQUIRED in large factory; excellent prospects. No person engaged on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4171 and this Journal. J 657

Draughtsmen Wanted for Aeroplane work in Government Factory. Previous experience in aeroplane design not absolutely necessary, but sound knowledge of mechanical principles essential. Good prospects for right men. No person already on Government work will be engaged.—Apply, stating experience, age, and salary required, to your nearest EMPLOYMENT EXCHANGE quoting reference No. A. 4126 and this Journal. J 628

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Draughtsman Wanted, with some knowledge of Blast Furnace work. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 750.

Draughtsman Required by Government Controlled Establishment, engaged on Aeronautical work, London, W.C. District. Must have had workshop experience and be capable of designing tools for repetition work. First-class salary will be paid to first-class man. No one engaged on Government work or resident more than ten miles away need apply.—J 762, Offices of Engineering.

Draughtsman Required in London district, with good general engineering experience. Knowledge of producer gas plant useful but not essential. State age, experience, salary required. Man preferred not eligible for military service.—Address, J 767, Offices of Engineering.

Draughtsman Required, with experience in the design and construction of high-pressure centrifugal pumps, &c. No one residing more than 10 miles away or already engaged on Government work need apply.—Address, stating age, experience and salary required, J 761, Offices of Engineering.

Mechanical Draughtsman Required, immediately, for engineering works in London district. General plant and millwright work, boilers, pipework, &c. No one at present on Government work need apply.—Address, stating age, experience, salary required and position regarding military service, J 775, Offices of Engineering.

Mechanical Draughtsman WANTED for large engineering works in Lancashire, conversant with gas engines, turbines, and general engineering work.—Apply, stating age, experience, and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning No. A4254. J 785

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A SIMPLE PROBLEM IN FORCED LUBRICATION.

By LORD RAYLEIGH, O.M., F.R.S.

THE important case of a shaft or journal running in bearings has been successfully treated by Reynolds, Sommerfeld and others. As Tower showed, the combination acts as a *pump*, and of itself, maintains the layer of lubricant between the opposed solid surfaces.* There are other cases, and some of them are of practical importance, where the layer can be maintained only with the aid of special devices, such as Michell bearings, or by the forcible introduction of fluid from outside, in order to compensate inevitable escapes. Thus, Fig. 1, when a shaft E with a flat end bears against a flat surface A B, the included oil tends to escape from the pressure, whether at C when the flat surface is continued, or at D when it is surmounted by a cylindrical cup. The permanence of the layer requires a continuous forcible feed, which may be through an axial perforation at F; for here, in contradistinction to the case of the journal, the rotation of the shaft does not avail. It is proposed to consider the problem thus presented, supposing in the first instance, that there is no cup. The small distance between the flat surfaces, *i.e.*, the thickness of the oil layer, is denoted by h, and the angular velocity of the shaft by ω. The motion is referred to cylindrical coordinates r, θ, z, where z is measured parallel to the axis of symmetry, and r is the distance of any point from that axis, Fig. 2. The velocities in the three directions are respectively u, v, w, and in virtue of the symmetry, they are all independent of θ. The motion is supposed to be *steady*, that is, the same at all times, and the inertia of the fluid is neglected. Under these conditions it is easy to recognise that w may be supposed to vanish throughout, and that v is given by

$$v = \omega z r / h \quad . \quad . \quad . \quad . \quad (1)$$

where z is measured from the fixed surface, so that v there vanishes.

In like manner the boundary conditions at $z = 0$ and $z = h$, as well as the equation of continuity, are satisfied by

$$u = C \frac{hz - z^2}{r} \quad . \quad . \quad . \quad . \quad (2)$$

where C is a constant. The total flow U, representing the volume of lubricant fed in unit time, which flows past every cylindrical surface of radius r, is

$$U = 2\pi r \int_0^h u \, dz = \frac{\pi h^3 C}{3} \quad . \quad . \quad (3)$$

When the inertia terms are neglected, and attention is paid to the symmetry, the formal equations in cylindrical co-ordinates† are

$$\frac{dp}{dr} = \mu \left(\nabla^2 u - \frac{u}{r^2} \right) . \quad . \quad . \quad (4)$$

$$0 = \nabla^2 v - \frac{v}{r^2} \quad . \quad . \quad . \quad (5)$$

$$\frac{dp}{dz} = \mu \nabla^2 w \quad . \quad . \quad . \quad (6)$$

p denoting the pressure and μ the viscosity, where

$$\nabla^2 = \frac{d^2}{dr^2} + \frac{1}{r}\frac{d}{dr} + \frac{d^2}{dz^2} \quad . \quad (7)$$

Of these (5) is satisfied by v in (1), and (6) is satisfied when $w = 0$ and p is independent of z. Also, with use of (2), (4) becomes

$$\frac{dp}{dr} = -\frac{2\mu C}{r} = -\frac{6\mu U}{\pi h^3 r} \quad . \quad . \quad (8)$$

so that

$$p - p_1 = \frac{6\mu U}{\pi h^3} \log \frac{r_1}{r} \quad . \quad . \quad . \quad (9)$$

where p_1 is the pressure at the outer radius r_1. If the layer is open at r_1, and we reckon only pressures above atmosphere, p_1 may be omitted.

The whole force sustained by the layer of fluid between the radii r_0 and r_1 is independent of ω, being given by

$$P = \frac{12\mu U}{h^3} \int_{r_0}^{r_1} r \log \frac{r_1}{r} \, dr$$

$$= \frac{3\mu U}{h^3} \left\{ r_1^2 - r_0^2 - 2 r_0^2 \log \frac{r_1}{r_0} \right\} \quad . \quad . \quad (10)$$

If we suppose $r_0 = 0$, so that the supply takes place on the axis itself, this becomes simply

$$P = 3\mu U r_1^2 / h^3 \quad . \quad . \quad . \quad (11)$$

but we have then to face an infinite pressure at the axis. In practice r_0 would have to be finite though small, and would correspond to the radius of the perforation in the lower fixed plate, not much disturbing (11). In fact, if p_0 be the pressure of the feed corresponding to r_0,

$$p_0 = \frac{6\mu U}{\pi h^3} \log \frac{r_1}{r_0} = \frac{2P}{\pi r_1^2} \log \frac{r_1}{r_0} \quad . \quad (12)$$

The moment of the forces due to viscosity, by which the rotation is resisted, has the expression

$$M = 2\pi\mu \int r^2 \, dr \left(\frac{du}{dz} \right)_0 = \frac{3\mu r_1^2 U}{h^2} \quad . \quad (13)$$

corresponding to (11), so that

$$M = h P \quad . \quad . \quad . \quad . \quad (14)$$

It may be worth remarking that if geometric similarity is preserved, so that r_1, r_0, h are in constant ratios, a consideration of "dimensions" suffices to show that P is proportional to $\mu U r_1^{-1}$,

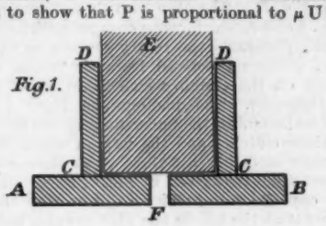


Fig.1.

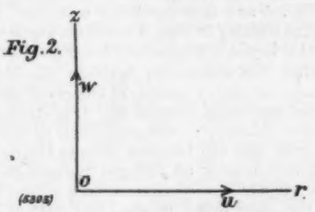


Fig.2.

(5202)

at least when we assume independence of the rotation (ω) which does not influence u. A deficiency of viscosity may thus always be compensated by an increase of supply.

The work which must be done in unit time to maintain the rotation is $M\omega$, or $h\omega P$. In addition to this, there is the work required to introduce the feed of lubricant, represented by $p_0 U$. Thus, altogether, for the work required

$$W = h\omega P + \frac{2PU}{\pi r_1^2} \log \frac{r_1}{r_0}$$

$$= h\omega P + \frac{2h^3 P^2}{3\pi\mu r_1^4} \log \frac{r_1}{r_0} \quad . \quad . \quad (15)$$

so that if P is given, a small h is favourable in respect of both parts. In practice the diminution of h calls for the utmost accuracy in fitting together the two opposed surfaces, which, however, need not be accurately plane, as well as the removal of all suspended solid matter from the lubricant.

When this is attended to, there should be *no wear* of the solid surfaces, which should never come into contact. To attain this ideal it is evidently necessary that the feed of lubricant should be established *before* the rotation commences.

It should be observed that no property of oil beyond viscosity is involved, and that the investigation may be expected to remain valid until the thickness (h) of the layer is approaching molecular limits.

P.S.—I may perhaps mention that I have made a small model, in which the opposed surfaces are those of two pennies ground to a fit, and the "lubricant" is water supplied from a tap.

* As was noticed at an early date by the present writer (President's address to British Association in 1884), this requires that the layer be thicker on the ingoing than on the outgoing side.

† Basnets' "Hydrodynamics," vol. ii, page 244, 1888.

THE SUNDERLAND GEAR PLANERS.

THE most remarkable advance which has been made in the formation of the teeth of gear wheels is one which is the growth of the present time—the substitution of methods of generation for those of form-cutting. It would be interesting to trace the history of the systems of approximation that have been employed from the time of Camus down to the present. The principles of the involute, and of the cycloidal teeth were stated by that writer, yet, though he died in 1768, approximations to the correct curves have been commonly adopted and retained, many of which have entailed a tantalising amount of juggling with the loci of the centres of the curves desired. One is amazed now that the more straightforward and accurate method—that of direct generation was not employed long since, The principle is simple, the results are precise. The explanation seems to be that the necessity for accuracy was not absolute in the days of slowly-running gears, as it is in these of high speeds, all-gear drives, electric transmission, and motor vehicles. The principle is that of a master gear, either a rack, or a pinion which imparts the correct shapes to the teeth of any gears of the same pitch. In principle the process is one of moulding, in practice it is that of cutting. The basis tooth is that of the rack with flanks having a pre-determined pressure angle. This may be embodied in a worm-like hob. Or a rack tooth can be used to generate a master pinion. Or the tooth may be employed directly as a cutter. Or several teeth can be included in a length of rack, sufficient in number to make contact with all the teeth that can be in mesh with the largest wheel to be generated in the system. The relative movements of the cutter and the blank are identical with those which will occur in the actual rack and its generated gear. Wheels produced thus will engage correctly with the rack and with each other, and without requiring any corrections or easing. The cutter is fed tangentially to the gear blank in the intervals of the reciprocations of the cutter across the face of the blank. This is the principle that is adopted in the Sunderland generating spur gear planer, manufactured by Messrs. J. Parkinson, of Shipley, which is illustrated in Figs. 1 and 2, on Plate LVIII, published with this issue.

The sequence of the action of the cutter is shown diagrammatically in Fig. 3, Plate LIX. The cutter is shown with four teeth. That actually used has five, six, or more in special cases. The cutter is shown as though moving round the gear, but the contrary movement takes place, the wheel blank rotating to present its periphery to the cutter which slides strictly in vertical and horizontal planes. The progress of generation is seen from the dotted tooth outlines to the full completed teeth. The blackened locations show the portions where the final shapes are being imparted. In action the cutter, suitably mounted on compound slides, with vertical and horizontal motions, is fixed, and the blank, carried on an arbor in the spindle of the dividing wheel, is brought up and set relatively to the cutter to give the correct depth of tooth. The cutter is traversed parallel with the axis of the blank when cutting, and tangentially to the periphery in the interval of the strokes, while the blank is receiving a rotary movement, the result being the formation of both flanks of the tooth spaces. The movements of the cutter and blank are synchronised to correspond with those of a rack and its gear in mesh. After a distance equal to one pitch has been cut, the movement of the cutter is arrested, and the rack is indexed backwards by a distance of one tooth, or pitch, after which the operation of cutting is repeated, and so on until the gear is finished. The action is a very gradual one, as may be seen on an inspection of the diagram, Fig. 3. No single tooth is finished at one indexing of the rack, but portions of several teeth are receiving their outlines simultaneously, either roughing, or finishing.

Passing from this statement of the essential principle which governs the action of the cutter, the broad outlines of the construction, and of the method of operation of the machine may be briefly noticed before taking up its minute details. It is shown by Figs. 1 and 2, Plate LVIII, the first being set up for cutting spur gears, the second for spirals or helical gears. A main shaft is driven from a pulley running at constant speed. It makes four revolutions forward to impart the feed to the cutter tangent to the periphery of the blank followed by four revolutions backward to cause the cutter to return to its starting position. While the reciprocating action of the cutter is proceeding, a very slight rotation of the blank takes place in the intervals of the strokes, until it has passed

through a distance equal to the pitch, when the cycle re-commences. Strictly, therefore, the tooth faces are a series of flats as in all gears that are generated from a rack, but the feed is so fine that a continuous curve is the practical result. The total vertical travel of the cutter, which corresponds with circular pitch, and the number of teeth to be produced on the blank are determined by two distinct sets of change gears, calculated for each respectively. Through these, the pitch line of the cutter and the pitch cylinder of the wheel blank are caused to travel at the same speed—being driven from the single pulley, and the same shaft—they operate in unison. This driving from a common shaft enables several carefully concerted related movements to be accomplished which are vital elements in the design of the machine, and which will be presently noted in some detail with the help of the diagram in Fig. 4. These are the stopping of the feed mechanism when it has operated through a distance equal to one pitch, and with it the arrest of the movement of the cutter, its reversal through a distance that is slightly greater than a pitch, the rotation of the blank backwards through a very small distance, while the cutter is being indexed to its starting point for the next pitch distance, and the operation of the feeds of the blank, and the cutter through a short distance before the cutting again commences, which is done in order that no lost motion shall occur at that instant when the cutter is set in motion. These indicate the precision of action of the machine due to the excellence of the provisions that are made to avoid all possible risk of error in results.

In the developed diagram, Fig. 4, the following elements are to be noticed. The blank is not shown, but the indexing wheel is partly outlined at A, and its worm at B. The indexing change gears which impart the rotary movements to the blank are shown at C. The set at D at the opposite end of the machine drives through mitre gears to the vertical lead screw E, which transmits the vertical motion to the cutter slide, partly seen in Fig. 5, and in the sectional detail Fig. 6, Plate LX, which causes the cutter to travel a distance equal to the linear pitch. The gears C, Fig. 4, for imparting rotation to the blank must be of such a ratio that the angular movement of the blank on the pitch circle shall exactly equal the travel of the cutter, and as both movements are connected they operate at the same speed and synchronise. The gears at C are calculated according to the number of teeth in the complete gear to be cut, and those at D to impart the pitch.

The intermittent motion is imparted to the shaft F, Fig. 4, by a special ratchet wheel G, having notches pitched unequally, to be referred to later. The pawl which engages and moves the ratchet is not visible. The ratchet, enclosed in a casing is keyed to a boss on one side of the freely running gear Q, seen adjacent to the right. The latter engages with a clutch *l* on its right, which is seen to be feather-keyed to the shaft F. This, when slid towards the right becomes disengaged to stop the feed, thus rendering it intermittent. The clutch movement is controlled by the inclined face cam H, which is mounted on a bush that revolves with the shaft F, and is slid along it on a feather-key. The internal thread of the bush engages with a fixed boss correspondingly threaded, the result being that the rotary motion of the bush produces endlong movement of the cam. The shaft F makes the four revolutions already mentioned for a feed of one pitch, consequently the endlong movement amounts to four times the pitch of the screw, which is cut within the cam bush. This motion occurs in a direction towards the right of Fig. 4 when feeding, towards the left when reversing.

When the cycle of movements has commenced, the pawl acting through the ratchet wheel G, its clutch *l*, and the shaft F causes three out of the four revolutions to take place before the cam H comes into action. But at the end of the third revolution one inclined face of the cam strikes a projection seen on the rod J "to stop feed," moving J in the direction of the arrow. The other end of the rod is connected through a pin with the lever K; compare with the detail in the lower part of Fig. 4, A second pin in the lever K connects it with a yoke lever that controls the movements of the clutch *l*. There is sufficient play left between the pin and its hole in the yoke lever, as seen in the detail below, to allow of the angular movement given to the lever K to take place without disturbing the engagement of the ratchet clutch *l*. But at the end of the fourth revolution, the additional movement that is imparted to the stop rod J, consequent on the further displacement of the cam H, causes the withdrawal of the clutch *l* from its gear Q, this action stopping the feed.

The way in which the movement of the cutter is arrested, also through the medium of clutches, seen in the upper left hand portion of Fig. 4, is now to be traced. The holder which carries the rack-shaped cutter is mounted on the reciprocating slide *r* Fig. 4, being also marked *r* in the detail, Fig. 6. The length of stroke of the slide is adjusted by the bolt seen in Figs. 4 and 6, and marked 53 in the photograph, Fig. 5, which bolt is moved across the face of the crank disc *a* in Figs. 4 and 6, and numbered 5 in Fig. 5. The disc carries a sliding clutch *e*, Figs. 4 and 6, which, when engaged with its meshing clutch *f* imparts the rotary motion to the crank disc, a motion derived from the worm wheel *g* keyed on the clutch, which worm wheel revolves continuously. The photographs Figs. 7 and 8 will be helpful to the understanding of the relations of these clutches and the way in which they act. It must be noted that these views show a different aspect from that given in Fig. 4, being taken from the opposite sides, which explains why the worm wheel is at the left in the photographs, but on the right in the drawing. Again the sliding clutch *e* in Figs. 4 and 6 is numbered 6 in Figs. 7 and 8, and the clutch *f* in Figs. 4 and 6 on which the worm wheel is keyed is numbered 10 in Figs. 7 and 8.

When the connection between the clutches is broken, the rotary motion of the crank disc *a*, and that of the cutter slide *r*, Fig. 4, is stopped in the manner following: Referring back to the cam H, a second cam will be observed *h* to the right of the first, and forming an integral portion of its bush This will strike a projection on a tilting boss L—see the small detail in the lower part of Fig. 4—shortly before the cam H strikes the projection on the stop rod J. The boss L has teeth on one end of its periphery to mesh with the rack teeth on the under side of the sliding rod M, seen above the shaft F, and in the detail below. When therefore the cam strikes the boss and swivels the boss L in its bearings, which are seen situated above and below the cam boss, the rod M is moved in the direction of the arrow "to stop cutter slide." A spiral pinion, seen at the extreme left of the rod M meshes with a spiral segment on the end of the lever *n*. The rod M cannot rotate, and therefore its endlong motion imparts a small angular displacement to the lever *n*. The shaft which carries this lever also carries the lever 9—compare with Figs. 7 and 8—which has an inclined face at the left in Fig. 4, and marked 8 in Figs. 7 and 8. This face swings up from the position shown in the photograph, Fig. 7 into the path of a projection on the clutch 6, so located as to disengage the two clutches, as seen in the photograph, Fig. 8. This occurs when the cutter slide *r*, Fig. 4, is at the back end of its stroke, that is, clear of the blank, after the completion of the idle stroke.

At the right hand of the photographs, Figs. 1 and 2, a lever and quadrant, with locating holes are seen. These regulate the feed for the strokes of the cutter. The strokes per tooth for different machines range in number from 20 to 40. For four sizes of machines, cutting to No. 3 diametral pitch, or 1 inch circular pitch, the strokes per tooth are 20, 24, 28, 32 and 36. For one heavy machine cutting to 1¼ diam. pitch, or 2½ in. circular pitch they are, 24, 32, 36 and 40. The insertion of the lever in the selected holes in the quadrant regulates the number of strokes. The feed is transmitted to the gear box seen in the diagram, Fig. 4, through the ratchet wheel G in that Fig. The two photographs, Figs. 9 and 10, show the lever put into the position of no feed, and that of full feed respectively, the intermediate holes affording the included range. The notches in the ratchet wheel G, Fig. 4, are not pitched uniformly, but there are certain arcs left smooth, on which, when the feed pawl rests, no movement is imparted to the gears in the box. This happens when the lever occupies the lower hole in the quadrant as it does in Fig. 9. But when it is moved to the hole next above, the pawl will catch a notch in the ratchet and the feed will operate, and will be increased by the insertion of the lever in successive holes until the maximum is reached in the fifth hole, Fig. 10.

Since the action of the second cam *h* at the right hand of the one H, Fig. 4, and which is carried on the same bush as H, takes place before that of the latter, which action of *h* stops the feeding motion received from the pawl and ratchet wheel G (because the pawl is driven from the shaft *q* Fig. 6) it is necessary to give the cam H some small additional movement to enable it to complete its work, thus:—

When the sliding stop rod M, Fig. 4, is moved along, causing the cutter slide to come to rest as just now described, it carries the upper end of a yoke lever along with it, which brings the sliding clutch *j* into mesh with the clutch on the gear, N, seen to the left of the clutch in Fig. 4. Clutch *j* is always engaged with a spiral gear O to the right, which is driven by the spiral pinion seen in broken lines beneath it, which pinion is on the same shaft as the continually-running belt pulley P, and thus the gear N is set in motion. N drives through an idler the wheel Q seen below it on the shaft F, thus completing the sequence necessary to withdraw the clutch to the right of Q, with the results stated.

The return movement of the cutter is effected as follows:—When the sliding rod J, Fig. 4, is moved along at the third revolution of the cam H, the lost motion between the lever K and the yoke lever which it operates is utilised to compress a spring plunger at *k*, of the common load and fire type, seen in the detail in the lower part of Fig. 4. When the shaft is at the end of the fourth revolution the rod J is again displaced, and the clutch *l* is withdrawn. The clutch does not remain in a middle position, but is forced into engagement with the spiral gear R seen to the right. This is the result of the action of the spring *k* in pushing its plunger down immediately the apex of the lever K has passed the tip of the plunger. The spiral gear R is always running in the opposite direction from that of the spur wheel Q, as is indicated by the arrows on each; and in consequence of its direct engagement with the spiral gear O, the clutch *l* and the shaft F revolve in the reverse direction, carrying the change wheels D and the mitres that drive to the lead screw E with them. The movements for feed and reverse are indicated by the two arrows drawn on the spur gear S to the right of the spiral R.

The provision that is made for indexing may next be considered. As already stated, this is done by moving the cutter back through a distance of one tooth, instead of moving the blank round by that distance. This "stepping" is effected by reversing the rotation of the shaft F through rather more than four revolutions, but without rotating the shaft T, Fig. 4, through which the movements for the rotation of the blank are transmitted. This statement as to the non-rotation of the shaft T is not strictly correct for all the machines, but in these exceptions the amount is very minute, in order to correspond with the excess movement of the cutter slide, and therefore the provision made for effecting it need not be described.

It will be observed that the cam H, Fig. 4, has two faces, only one of which has been accounted for as yet in the description of feeding. The reverse motion is stopped by the other or left-hand face striking a second projection seen on the sliding rod J. This imparts the exact reverse of the previous movement of the rod J. This brings the clutch *l* on the shaft F back to the feeding position again—for, seeing that gear Q is still revolving, driven by gear N, the clutch *l* must revolve in the feeding direction. It should be noted, also, that the clutch teeth of the wheel Q and those of it, mating face on the clutch *l* are so made that they can only engage in one position, which is arranged in order to maintain the correct relative positions of the ratchet wheel G, and of the bush which carries the two cams H and *h* for moving the feed bar J.

Although the feeding movements of the blank and cutter will operate in unison, the actual cutting does not commence immediately following reversal, but during the movements for feeding, the cutter feed and that for the blank are brought into "step," to effect which is the object of making the slight excess return movement mentioned. This excess is recovered during the initial feeding movements of the blank and cutter in the following manner:—

While the excess movement of rotation of the shaft F was proceeding, the cam bush travelled along its screw to the left. While the excess is being recovered, the right-hand cam *h* approaches another projection on the opposite side of the tilting boss L to that which is occupied by the projection used for stopping the cutter slide. The projection is free to swivel on the pin, as seen in the detail below, when the cam strikes it during the reverse motion. But when it is struck during the feeding movement, the boss L is tilted back to its original position, and this motion is transmitted to the lever 9, Figs, 4, 7, and 8. But now the lever 9 is withdrawn, leaving the sliding clutch at 6—the left-hand one in Fig. 4, the right hand in Figs. 7 and 8—free to slide into engagement with the revolving clutch *f* to the right in Figs. 4 and 6, and marked 10 in Figs. 7 and 8. The engagement is accomplished smartly by the action of four springs, one of which is seen in Fig. 4, and thus the cutter slide is started. For the moment, also, the clutch *j* is withdrawn by its yoke lever from the gear N, and this has the effect of stopping the feed motion temporarily, until the resumption of the movement of the cutter slide restarts the intermittent motion of the pawl and its ratchet G. The taking-up of the excess movement will bring the square side of the notch in the face of the gear U into line with the spring plunger seen to the left of it, allowing the plunger to engage. Hence when the intermittent feed comes into action again, both feed motions—that of the blank and the cutter—are in unison, and the generation will proceed as though no manner of separation existed between them.

A safety arrangement is provided to prevent the sliding clutch from disengaging from either of its mating clutches during the fourth revolution, whether forward or reverse.

It is effected as follows:—It will be remembered that when at the end of the third revolution the lever K, Fig. 4, was displaced, no movement was transmitted to the yoke lever that actuates the sliding clutch *l* on the shaft F. But, on the other hand, the lever K no longer holds the sliding clutch *l* and that in the wheel Q in engagement, nor the opposite face of the same clutch in mesh with its wheel R on the right hand (when reversing). To prevent them, therefore, from disengaging before the proper time, a second spring plunger is lightly pressed against a projection *o* on the yoke lever, the engaging faces being bevelled to give the necessary side pressure.

The possible slipping of the sliding clutch 6 in Fig. 4, and of its mounting on the tops of the teeth of its fellow *f* to the right, is prevented by the insertion of a friction disc shown at *h* in Fig. 6, keyed to the shaft *q* on which the crank disc *a* in Figs. 6 and 4 is keyed. It is pressed against a coned portion of the worm wheel *g* by means of the screw *n* in Fig. 6. When, therefore, the crank disc and its shaft come to rest, the friction disc *h* tends to revolve owing to the continued rotation of the worm wheel. But the effect is to keep the projection 7 on the sliding clutch 6 in Fig. 4, pressed against a stop on the lever 9, and thus well clear of the clutch *f* to the right.

We may now look into some details, which though of a minor character are contributory to the efficiency of the machine, to many of which no reference has been made in the previous description.

Fig. 6 which shows the main drive to the cutter slide is a complete section of the corresponding portion of the machine that is shown in outline only in Fig. 4; *g* is the worm wheel, *h* the coned friction disc, the function of which has just been stated, and which is adjusted with the screw *n*. To do this, the nut of the screw is slackened, then the screw is tightened slightly, and its nut is relocked, being careful that the screw *n* does not move while doing so. The crank disc is seen at *a*, and a portion of the cutter slide at *r* secured to the disc with a bolt, and adjustable across its face to produce variations in the lengths of stroke. Slippers *b* are provided for the disc, which are adjusted by first slackening the screws *d*, then tightening the screws *c*, and refixing *d*. The fit must not be made too close, or the slight expansion when running will cause friction and wear.

Referring back to Fig. 5, the face of the crank disc in that photograph is numbered 5, a portion of the reciprocating slide is seen at 52, and the adjustable bolt which regulates the length of stroke at 53. Two teeth of the cutter are seen in its holder just clear of the blank. Graduations on the crank disc which are hidden in the view indicate the widths of the faces of the gears to be cut, by means of which the positions of the crank pin are set with a cross-traverse screw. The length of stroke imparted is slightly in excess of that shown by its graduation in order to provide the clearance necessary for the cutter at each side of the blank. The cutter box is set and bolted in any required distance along the slide through the tee slots seen in Fig. 5, to suit the position of the blank.

Fig. 11 shows the blank-carrying slide, lettered to correspond with the table subjoined, which gives the dimensions of those elements for the standard machines. The smaller Fig. 12 above shows an alternative method for the two smallest machines made, in which a shorter mandrel with a No. 12 B. & S. taper can be substituted. The hollow spindle has a hole large enough to receive shafts on which their pinions are forged solidly. It has also a flange with a cross slot, for use when cutting gears that require a face plate. The master wheel is seen attached at the left, and a gear at the right with the adjustable steady outside it.

When mounting a blank, the dividing worm is temporarily disengaged. The hole in the spindle and the shank of the arbor are cleaned, and the truth of the arbor is tested with an indicator. The blank is set with as little overhang as possible. Its truth is also tested. When all is correct, the worm is re-engaged.

DIMENSION TABLE FOR WORK SPINDLE.

Size of Machine.	A.	B.	C.	D.	E.	F.	G.	Key H.	J.	K.	L.	M.	Keyway N.	P.
	in.	in.	in.	ft. in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
11	4	3½	3	2 11⅞	23½	5	4½	⅝ × ⅛	6	4½	10	1½	1 × ⅜	11½
9 and 9A ..	2½	2½	2	2 4⅞	19½	4½	4½	½ × ⅛	4½	3½	8	1½	⅜ × ⅛	9½
6 and 6A ..	2	1½	1½	2 0	16½	4	5	⅜ × ⅛	3½	2½	6½	1½	⅜ × ⅛	8½

DIMENSION TABLE FOR CUTTER BOXES.

Size of Machine.	A.	B.	C.	D.	E.	F.	G.	H.	J.	K.	L.	M.	N.	P.	Q.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
11	1½	2½	4½	3½	½	2½	2½	3	2½	3½	11½	4½	1½	4 × 1½	1½
9 and 9A ..	1½	2½	4½	3½	7/16	2½	9 1½ 9A 2½	2½	2½	9 3 1/16 9A 3 1/16	9½	3½	1	4 × 1½	2
6 and 6A ..	1½	2 1/16	3 1/16	2½	7/16	1½	1½	2½	1½	2 1/16	6	1½	1 1/16	2 × 1½	1

The detail of the bearing for the vertical feed screw is seen in Fig. 13. The screw controls the movements of the slide by which the vertical motion is communicated to the cutter holder. The lower part of the screw is seen in the photographs, Figs. 1 and 2, on the base of the machine, in the foreground, and also at E in Fig. 4. The weight of the slide is partly counterpoised as seen in Figs. 1 and 2 by a balance weight suspended from a chain passing over an arched head. End thrust of the screw in either direction is taken by the ball thrust collar A Fig. 13. Machines that are designed for cutting spur gears only have a long solid nut seen at B, but those which are arranged to include spirals have an adjustable nut in two parts as at C, Fig. 14, slack being taken up by the nuts D and E. This is done because of the increased end thrust which is encountered when spiral gears are being cut, and when the presence of any back lash would produce inaccuracies in the teeth.

The cutter box, Figs. 15 to 17, is dimensioned to correspond with the table annexed. The box is bolted to its horizontal, or angular-setting slide through the four lugs. Comparison may be made with the photographs, Figs. 1, 2 and 5. The cutter is placed in the slot with a plate inserted between it and the clamping screws, and with a backing plate behind it, seen in Figs. 16 and 17, and in Fig. 5. The approximate centre of the second tooth from the top of the cutter is placed opposite the setting mark, Fig. 15, on the cutter box. This setting is not required to be exact, being only located in order that there shall be sufficient length of cutter below the mark to fully engage the arc of contact of the blank, and to provide the starting point for reading the depth of cut—that of the length of tooth. The cutter is held with its back edge against the bottom of the slot in the box, and clamped.

In this connection the character of the cutters calls for some observations. Fig. 18 shows two cutters, which are of high speed steel, that have been reduced to extreme tenuity in working, an ocular testimony to their endurance. The one at the centre is of No. 8 diam. pitch, that to the right, of 4 diam. pitch. At the left a backing plate is shown. This is nearly of the full width of the cutter with which it is used, giving clearance spaces as seen in Figs. 17 and 5. Its use prolongs the life of the cutters, especially on heavy work. As will be observed from Fig. 18, the faces of the cutters are ground slightly concave, imparting a small amount of top rake to the edges. In action (compare with Fig. 3) the lower teeth rough, and the following teeth finish. When coarse pitches are being dealt with it is well to take preliminary gashing cuts, using a tool of the correct depth, but thin in the teeth, leaving the generation to be done by the finishing cutter, removing material from the sides only.

The generating process has the great advantage over the employment of form cutters in the fact that stronger teeth can be obtained in small pinions, without the sacrifice of any degree of accuracy. It is done by lengthening the *addenda* of the teeth, a device which is frequently adopted.

The standard cutters are made to the angle in most common use, namely 14½ deg. pressure angle, or 29 deg. included angles, and to the B. & S. length of tooth. But other cutters are supplied if required as 30 deg., 36 deg., and 45 deg. included angles, and to shorter lengths than standard. Special cutters are recommended for pinions of less than 20 teeth to avoid undercut. Cutters are also made for sprocket wheels. Cutters have different cross-sections of rectangular bar, which vary with pitch. They range from approximately 2½ in. by ⅜ in. section, to 4 in. by 1 in., which range includes seven distinct sections. The three largest are made for circular pitches embracing those between 2½ in. and 4 in. The four smallest are for circular, diametral, and module or metric pitches.

These machines are also designed to cut spiral or helical gears in addition to spur wheels. The difference made is that the cutter slide is mounted on a swivel base, Fig. 2, so that it may be set to cut at the desired angle of the spiral. The helical teeth are cut by the same movements as the spurs are, subject to the setting of the cutter at an angle with the face of the blank. And the same cutters are used for both, provided that the normal pitches of

the spiral gears are those of the standard spurs. If they are required of fractional pitches, which should be avoided when possible, extra cutters are necessary. Another exception occurs in large spiral gears of steep angles, when cutters of greater length than the standard will be required, to include more teeth.

Fig. 19 shows a spiral gear being cut, but the rim stay A has been moved to expose the cutter to view. When setting up the machine for cutting these gears, two elements only have to be taken, the pitch and the angle of inclination of the teeth. The total lead or axial pitch of the helix of which the teeth form a short length is not taken note of, as is done in milling machine practice. The angle of inclination is set by swivelling the cutter slide to that angle. The change gears for pitch are selected for the real circular pitch, and the cutter is chosen for the normal pitch. The pitch taken normally to the direction of the spiral is the shortest distance between contiguous teeth, and is distinguished thus from the pitch that is measured round the face of the gear, and which varies with every variation in the angle of the spiral. Any two gears that are produced with a cutter of a given normal pitch will mesh correctly, but the face pitches will only correspond when the wheels are of equal angles, 45 deg., and equal in diameter. Therefore the face pitch is ignored so far as the selection of cutters is concerned. Only the real circular pitch enters into the calculation of change gears, and the spur gear cutter for the normal pitch will shape the spiral gear correctly.

The cutter slide is set to the required angle by means of the graduations on its swivel base, which is fitted with a vernier. The swivel base is graduated in degrees. The vernier has twelve divisions which occupy the same space as eleven degrees on the base, whence divisions of degrees and minutes of arc are set. A longer stroke of the cutter is required when planing spirals than is taken for spurs of equal width, in order that it may clear the blank at each end of the stroke. There is a difference to be observed when cutting right and left-hand spirals. When a right-hand spiral is being planed the cutting stroke is upwards. Then the feed should be downwards in order to keep the feed screw, Fig. 4, E, and Fig. 13 in compression. If the angle of the spiral is a steep one, the weight of the counterpoise is reduced by removing loose weights that are provided. Then the cut commences light, and increases in thickness. The pressure of the cutter holds the teeth of the dividing wheel against those of its worm, and maintains the worm in contact with the thrust collar, so that any backlash present in the feed screw or in the dividing wheel and worm does not appear in the cut. The downward feed is obtained by means of an additional intermediate change wheel, in each train of change gears. When planing left-hand spirals, the cutting stroke is downwards, and the feed upwards. Then, as the pressure of the cutter tends to lift the slide, the counterpoise should be increased to keep the vertical feed screw in tension. The torsional strain is greater in cutting spirals than spurs, and it increases with the angle. For this reason the blanks for spiral gears should be held very securely on their arbors, and if of large diameters be keyed to the spindle, or to a face plate mounted on it.

The following particulars apply to all the Sunderland machines. Three sizes of spur gear planers are numbered 6, 9 and 11 respectively for spur gears. The No. 6 machine cuts gears from 2 in. to 2 ft. diameter × 8 in. face, and to 1-in. circular pitch, or No. 3 diametral pitch. The No. 9 cuts from 4 in. to 4 ft. diameter × 9-in. face, and to 2 in. c.p., or No. 1½ d.p. The No. 11 cuts to 6 ft. diameter × 10½ face, and to 2½ in. c.p., or No. 1¼ d.p. The No. 6A and No. 9A machines are made to plane spiral gears in addition to spurs. They have the same capacities as the No. 6 and No. 9 respectively. The general aspect of the two designs is shown by the photographs Figs. 1 and 2.

In all machines the driving is done from a line shaft to fast and loose pulleys which run at a constant speed, on the further side of the machine in Figs. 1 and 2. Provision for an electric motor is made by machined seatings on the main casting to receive an angle bracket. The main framing comprises a horizontal bed on the farther side, along which the work head is moved, a vertical column on which the cutter slide is carried, and a support in the foreground which receives the outer support for the wheel arbor. A tank occupies the central portion which, in addition to its proper function of receiving the cuttings helps to increase the rigidity of the base. The gear box is carried on an extension of the base seen at the right hand in Figs. 2 and 3. The lubricating pump is in front of it. The sliding work-head carries the horizontal spindle, into which the arbor is fitted on which the blank is mounted. At the other end of the spindle the master worm wheel A, in Fig. 4, is mounted. The worm B in Fig. 4 is carried on a pivoted shaft to be dropped out of engagement when adjustments of arbor and blank are being made. The wheel head is moved horizontally along the bed when setting gears for depth of cut, with a lever seen at the left hand of the bed, in Figs. 1 and 2, but located at one side in the heavier machines. Precise movements are indicated by the graduated dial, after which the slide is clamped on its ways. In Figs. 1 and 2, two horizontal shafts are seen projecting from the side of the machine. The upper one can be used for moving the wheel slide along the bed. The lower one is for dividing by hand when a blank is having its teeth roughed out with a single cutter, preparatory to the actual generation. This is of value when steel gears are cast with tooth spaces, with a view to lessen the tooling, and to reduce the dangerous shrinkage strains consequent on the heavy mass of metal in a solid rim tied to relatively light arms.

The subsequent illustrations show some important details relating to the mounting of different gears to be cut. Two principal conditions exist, the avoiding of spring and distortion consequent on clamping, and the economies of cutting in multiple.

In Fig. 20 a special plate B is used to bolt to an existing face plate A, to carry a large ring gear C. The plate B is set back in order to avoid overhang, which would conduce to spring and chatter under heavy cutting. Alternatively A and B might be made in a single plate if considerable numbers of ring gears were required. In this, as in all the larger wheels, a rim rest is used in opposition to the pressure of the cutter. In Fig. 21, a large wheel is shown driven by a dog B, bolted to the driver plate A, and bearing against one of the arms. Two dogs are used, set on opposite sides of the centre, but one only is shown. Fig. 22 shows two gears mounted for gang-cutting. Here the blanks C, C, are gripped by their rims which are in contact. A clamping ring B is fitted to the driver plate. Another is centred on the work arbor bush E, and the bolts pass through both, being located as near to the rim as the rim stay will permit. Fig. 23 shows four ring gears arranged for gang-cutting. A special carrier plate and rim is prepared, and a ring is attached to the rim with stud bolts. The clearance left between ring and rim enables the pressure to be put on the gears. At Fig. 24 a wheel C is shown which has a large face at D, convenient for clamping against a plate A. Two methods of holding are shown, one through a bush B, the other an annular washer at E, taking a bearing against the plate of the wheel.

In Fig. 25 a pair of gears C, cast together, are mounted on a mandrel. For the pinion an "upset" cutter is used, carried on an extension plate. A heel, dotted at B, will afford additional support to resist the pressure of the cut. Fig. 26 illustrates a method of adjustment suitable for pinions that are forged solidly with their shafts, and that overhang a considerable distance from the work-carrying head. A bush B centralises the work, and the clamping screws A are adjusted until the blank C runs truly. D is an outer supporting bush. Collars are provided at E to afford increased latitude endwise. This is for use in those machines where the outer support has adjustment towards the spindle. If bushes are inserted at F, shafts of various diameters can be accommodated. Fig. 27 illustrates a method of mounting a small pinion with a shank, having a screwed end, on machines in which the outer support has adjustment toward the spindle. A bolt from the back end of the spindle forces the tapered split collet A into its holder, thus gripping the collet on the gear shank. When mounting a gear, the collar B serves as a pilot to start the nut C. But the final grip is obtained by tightening the nut D with one spanner, while the nut is prevented from rotating with another spanner on nut E. A plug F in the outer supporting bearing G affords additional

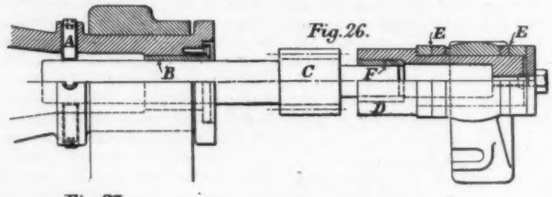


Fig. 26.

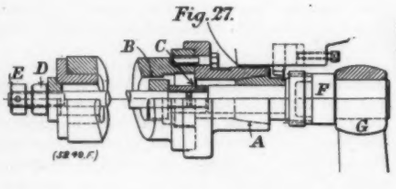


Fig. 27.

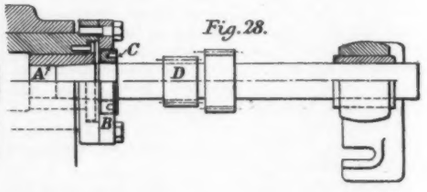


Fig. 28.

support. Fig. 28 shows another method of mounting pinions forged solidly with their shafts. In this case when cutting gear D, the shaft is not long enough to reach the screws seen at A, in Fig. 26. A special bush, therefore, at A with a tapered hole, fits the hole at the front end of the spindle, and a cap B with an internal thread of, say, 8 per inch, is fixed to the spindle flange. The end of the gear shaft, tapered to fit the bush A, is screwed, say, to 12 per inch to be an easy fit in a nut C, which is threaded externally to fit the cap B. Through this differential threading of C a good grip is obtained on the shaft.

Prevention of Electrolysis in Iron Concrete.—Some new experiments on the corrosion of iron in ferro-concrete are described by W. A. Del Mar and D. C. Woodbury in the *Electrical World*, of November 10, 1917. They embedded iron rods in blocks of concrete, one or three rods in each block, and so connected the rods on a 120 volt. circuit that some rods were anodes, and some cathodes, and some not joined up. The blocks were placed in pails filled with water from the mains. The anodes were afterwards found corroded; the other rods were almost intact. The resistance (i.e., the ratio volts./amperes) increased during the current flow, diminished considerably when the current was broken, and rose again slowly on re-establishing the circuit. This fall of resistance the experimenters' ascribe to electricosmosis, which they demonstrate in the following way. A V tube was partly filled with iron rust, and water was poured over the rust in the one limb; electrodes were inserted in the two limbs; a current of 0.05 amp. then moved 1 cb. cm. of water in four hours from the side, through 10 cm. of rust in a tube of 7 mm. internal diameter, over to the other limb. By reversing the current, the water was afterwards sent back again into the first limb. This is, of course, a well-known phenomenon, which the late Botho Schwerin utilised with success for dehydrating wet pulps and precipitates, and with less success for dehydrating peat. A rod of painted iron, Del Mar and Woodbury found, developed bubbles under the film of paint when cathode, but not when anode, in water, the water being forced through the paint. Hence the further corrosion is prevented, they conclude, by the making of rust which acts as a porous cell and becomes dry by enclosure, or can also be prevented by coating the iron rod with a paint which is an insulator. The paper mentions only a few experiments, we should say, all of which seem to have been made with currents of 120 volts.

THE COST OF ELECTRIC PIG IRON PRODUCTION IN NORTH SWEDEN.

THE number of electric furnaces engaged in the production of steel is increasing in this country at a very rapid rate, although all the current is produced by steam power. It would certainly be commercially impossible to produce pig-iron in this way on account of the expense, but in countries where hydro-electro power is available at a cost of 35*s.* to 40*s.* per kilowatt year the prospects of such a process are somewhat more promising. The subject is attracting much attention in Norway and Sweden, and in the latter country the production of electric pig-iron has already assumed some tangible dimensions with every likelihood of further important and rapid extension. Already 19,200 k.w. are being employed at four works, with six furnaces. This corresponds under the present conditions with a production of 65,000 tons to 70,000 tons of pig-iron and a consumption of 110 000 tons to 120,000 tons of iron ore and about 25,000 tons of charcoal per annum. As Sweden's richest iron ore deposits in its northern districts are located, so to speak, side by side of the largest waterfalls, this district offers the most promising site for an electric iron industry.

The three main factors to be considered in the electric production of pig-iron are the fuel for the reduction of the ore, the ore and the power.

The Fuel.—The experience gained so far by the working of electric smelting furnaces has shown that coke as a medium of reduction is out of the question. Both at Trollhättan and at Tyrse, on the Hardanger Fiord, Norway, this has been found to be true and the experimental working has been discontinued at the latter place. As far as can be seen at present the use of peat, and of peat charcoal, is also out of the question. There remains only wood charcoal, and preferably charcoal from round timber, and not saw mill charcoal.

The vital point in considering to what extent electric pig-iron production, based upon the North Swedish iron ore and the North Swedish water power, can be carried, therefore naturally hangs on the supply of charcoal on the spot. In this connection it must be remembered that Sweden's already existing iron industry to a great extent obtains its supply of charcoal from North Sweden. It would therefore be undesirable for an increasing electric pig-iron industry to draw upon this charcoal, if that would jeopardise the existence of Sweden's old iron industry. It must first be ascertained how much charcoal will be needed in the aggregate, since each ton of pig-iron calls for 350 kg. to 400 kg. of charcoal.

The Iron Ore.—Of the ore which is at present being worked in the Lapland mines, the Tuolluvaara ore is the most suitable for electric smelting on account of its high percentage of metal, and of the size and shape of the pieces. The A ore from Kürunavaara is somewhat richer in iron, but also in sulphur, and consequently requires a certain quantity of limestone to produce pig-iron sufficiently free from sulphur. Briquettes or concentrate of Gellivara "varp" ore should also prove suitable for electric pig-iron production, as may also certain other ore deposits in Lapland, for instance the Leveeänienic and the Mertainen ore.

In the electric process as followed in Sweden, the ore is put into the furnace unroasted. This is possible, because the percentage of sulphur is low and because it is neutralised by a certain amount of manganese. The Lapland ores, are, however, all poor in manganese, and it is therefore questionable whether they will not need to be roasted, at least in the case of the Kürunavaara A ore. Much in this connection depends upon the variety of pig-iron produced, for experiments at Trollhättan showed that the percentage of sulphur in half-white iron was entirely satisfactory, whilst on the other hand it became too high in all-white iron. This permissible percentage of sulphur depends upon the condition whether the pig-iron is to be used in the home steel works or exported, for in the latter case the demands are generally more stringent. It should also be pointed out that sulphur is productive of more difficulties in the electric pig-iron process, than in the blast furnace, for in addition to the sulphur contained in the ore, some generally enters from the electrodes. Roasting the ore, of course, increases the cost. The Lapland phosphoric ores cannot with advantage be smelted in electric furnaces. The process is far too expensive for the production of low-quality iron.

The Power.—The phrase power consumption can be taken in two senses. In the first place it may mean the number of k.w.h. which, according to the meter, are consumed per ton of pig-iron, and secondly, that number of k.w.h. which an installation of a certain capacity requires for its permanent working. The former, as a rule, is less than the latter, for the electrical furnace has to pay a certain fixed sum per year for a certain number of kilowatts determined by the maximum demand. If, therefore, it is a question of trying to determine how many tons of pig-iron can be produced per kilowatt year, it will be necessary to state, whether the number of tons is to be reckoned per purchased kilowatt year or per measured number of kilowatt-hour reduced to kilowatt years. In the latter case the load factor asserts itself. If the payment for the power is represented by a certain fixed sum per year, the problem is to utilise this power to the utmost, and for this purpose there must be several furnace units.

The working of the Trollhätten electric furnace during the years 1913, 1914 and 1915 may be taken as an example of this. At the disposal of the electric furnace, these were 2,208 kw. The production during the three years was: In 1913, 7,334 tons; in 1914, 7,049 tons; and in 1915, 7,502 tons; which comes out at a production per purchased kilowatt year of, 3.32 tons in 1913, 3.19 tons in 1914, and 3.40 tons in 1915. With these figures there must be compared those arrived at by calculation, on the basis of the total number of measured kilowatt hour in the respective years, viz.: In 1913, 4.05 tons; in 1914, 4.00 tons; and in 1915, 3.92 tons. Of the disposable power, there were, consequently, utilised in 1913, 82.0 per cent.; in 1914, 79.8 per cent.; and in 1915, 86.7 per cent.; or, on the average, about 83 per cent.

These figures, based on the experiments at Trollhättan, should be fairly well applicable in North Sweden, and in a works using only one furnace there should be obtained a production of 4 tons per kilowatt year, measured by a meter at the furnace, and 3.32 tons per purchased kilowatt year. Better results may be expected from a plant of two, three or four furnaces. With a plant of four furnaces, it is assumed that an efficiency of 92 per cent. can be attained, and with two or three furnaces, between 83 and 92 per cent. respectively.

The output would thus be:—

Number of Furnaces.	Production of Pig-Iron		Number of Purchased Kw. Year per Ton.
	per Kw. Year Measured at the Works.	per Purchased Kw. Year.	
	tons.	tons	
1 ..	4.00	3.32	0.301
2 ..	4.00	3.44	0.291
3 ..	4.00	3.56	0.281
4 ..	4.00	3.68	0.272

In a plant of four furnaces three should be worked regularly, and the fourth held in reserve, except when an excess of water power is available.

The power required in an electric furnace depends upon the percentage of iron in the ore, and on the other constituents. The kinds of iron ore suitable for electric smelting in North Sweden are both rich and pure. It has yet to be determined whether an electric furnace can be run with different amounts of power at different times of the twenty-four hours, or of the year, and how great deviations are permissible.

As regards the question of variations through longer periods, the working at Trollhättan affords some information. As already mentioned, the furnace is built for 2,208 kw. The average load during work, according to measurements, amounted to:

November 5, 1910, to May 29, 1910—
1,302 kw.* (about 68 per cent. of 2,208 kw.).
August 4, 1911, to June 21, 1912—
1,577 kw.* (about 73 per cent. of 2,208).
August 12, 1912, to September 30, 1912—
1,728 kw.* (about 78 per cent. of 2,208).
August 12, 1912, to December 31, 1912—
1,833 kw. (about 83 per cent. of 2,208).
* 75 kw. added for motor and lighting.
The year 1913, 1,987 kw. (about 90 per cent. of 2,208).
The year 1914, 1,980 kw. (about 90 per cent. of 2,208).
The year 1915, 1,962 k.w. (about 89 per cent. of 2208).

without any technical difficulties ensuing.

What will be the effect of variations during the twenty-four hours it is more difficult to decide, but presumably they will cause some inconvenience, because it is impossible always to meet the altered heat conditions in the furnaces.

The Location of the Works.—As to the site to be chosen for the works, it should be where the cost of charcoal, iron ore and power will be a minimum. In the following calculations which have been made in connection with the Jernkontoret, the Iron Institute of Sweden, in order to be on the safe side, the consumptions of ore, charcoal and power per ton of pig-iron produced has been taken at 25 hectolitres (400 kg. of charcoal) 1,600 kg. of iron ore, and 0.272 kw. year. The consumption of limestone will hardly influence the result. The weight of iron ore, it will be seen, is four times that of charcoal; so this is an important factor in the choice of a site.

As an example of the outlay in connection with an electric smelting plant, and of the cost of the iron, an estimate has been made of plants respectively at Lulea and Gellivare, for an installation of about 8,000 kw. (measured at the works) and four furnaces. With the prices current before the war, and exclusive of housing for officials and men, the cost of a plant of this nature would be at Lulea, about 86,000*l.* = 10*l.* 8*s.* per kilowatt; and at Gellivare, about 95,000*l.* = 11*l.* 7*s.* per kilowatt. For houses, there must be reckoned, at Lulea, about 21,000*l.*, and at Gellivare about 23,000*l.*

The Cost of Production of Electric Pig-Iron.—In these calculations the following prices are taken:—

	At Gellivare. sh.	At Lulea. sh.
Iron ore and briquettes, 50 per cent. of each per ton...	11.4	13.5
Charcoal ... hectolitre	0.84	0.72
Electric energy, measured at the furnace, per kilowatt year	52.9	74.8

There is assumed a staff of six officials and 75 foremen and men for a production of 30,000 tons of pig-iron per year. The following calculation of costs has been made of this basis.

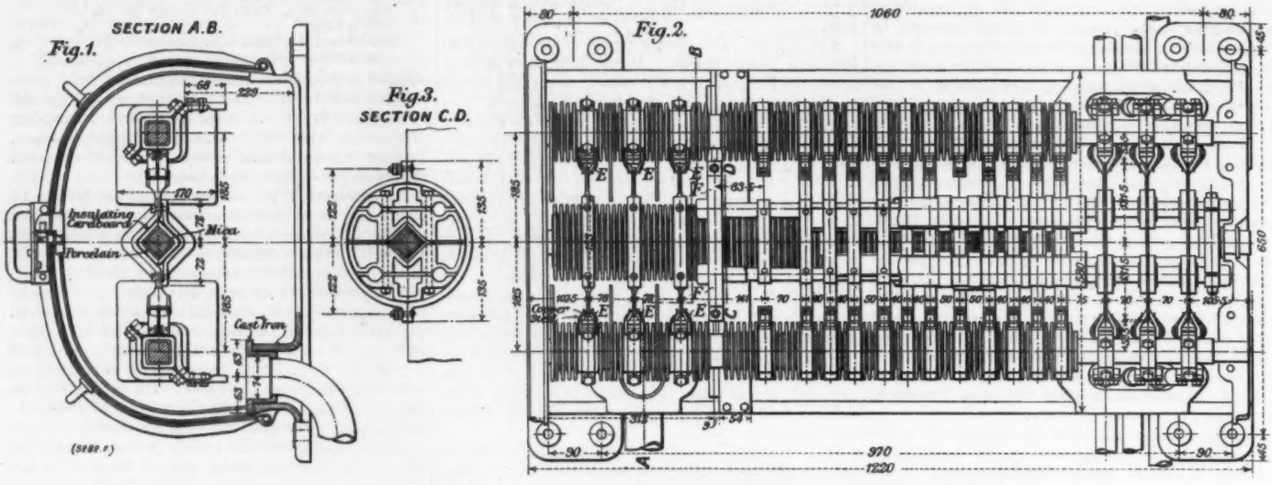
	At Gellivare. sh.	At Lulea. sh.
1,600 kilogramme ore ...	18.24	21.60
Limestone	0.67	0.44
25 hectolitres charcoal ...	20.83	18.05
0,272 kilowatt year	14.40	20.34
Electrodes	1.84	1.66
Repairs	3.66	3.33
Wages	6.54	5.44
Management, &c.	2.22	1.94
Royalty (to owner of land)	1.40	1.36
	69.80	74.16
Sinking fund	3.61	3.28
Interest	5.72	5.40
	79.13	82.84

If the iron is assumed to be shipped by water from Lulea to Swedish consumers, a freight of 5.92 sh. (under tariff 11) or with 20 per cent. reduction, 4.70 sh. per ton will have to be added, in order to obtain a fair comparison for the railway transport from Gellivare to Lulea, which would make the price for the Gellivara iron, 83.80 sh. per ton; for the Lulea iron, 82.84 sh. per ton. Further transport from Lulea to Gäfle and reloading on to railway trucks at this place costs about 4.4 sh. per ton, so that the price will be 87.20 sh. to 87.70 sh. per ton, that is, a price so high that it cannot compete with the corresponding Bergslag pig-iron (from the central Swedish iron industry), in as much as the corresponding price for the latter, before the war, was 72.22 sh. to 77.77 sh. per ton for basic Martin pig-iron and 77.77 sh. to 83.33 sh. per ton for acid Martin pig-iron. In order to make the Lapland electric pig-iron capable of competing, a material reduction in the cost of the electric energy, amongst other things, is essential.

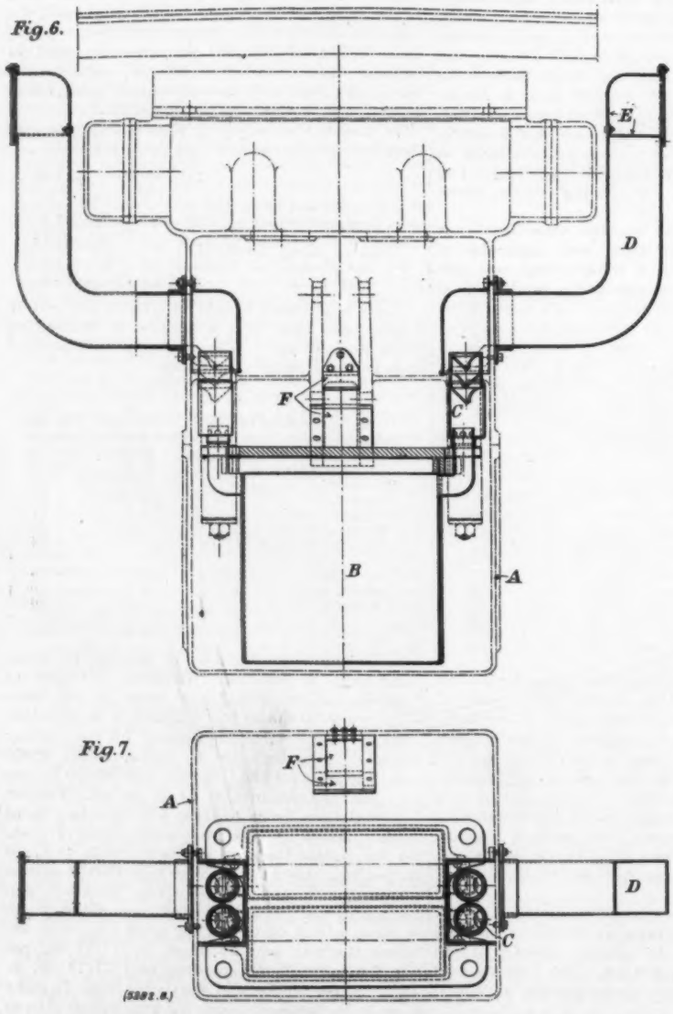
It has been suggested that it would be desirable

DEVELOPMENTS IN ELECTRIC LOCOMOTIVES IN ITALY.

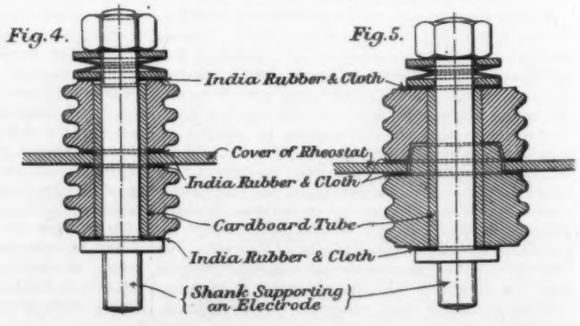
(*For Description, see opposite Page.*)



Figs. 1 to 3. Speed Regulator for Three-Phase Cascade Traction.



Figs. 6 to 8. Modifications in Automatic Oil-Brake Switches to Prevent Escape of Burning Oil.



Figs. 4 and 5. Original and Modified Means of Suspension of Electrodes in Liquid Rheostat.

DEVELOPMENTS IN ELECTRIC LOCOMOTIVES IN ITALY.

Fig. 9.

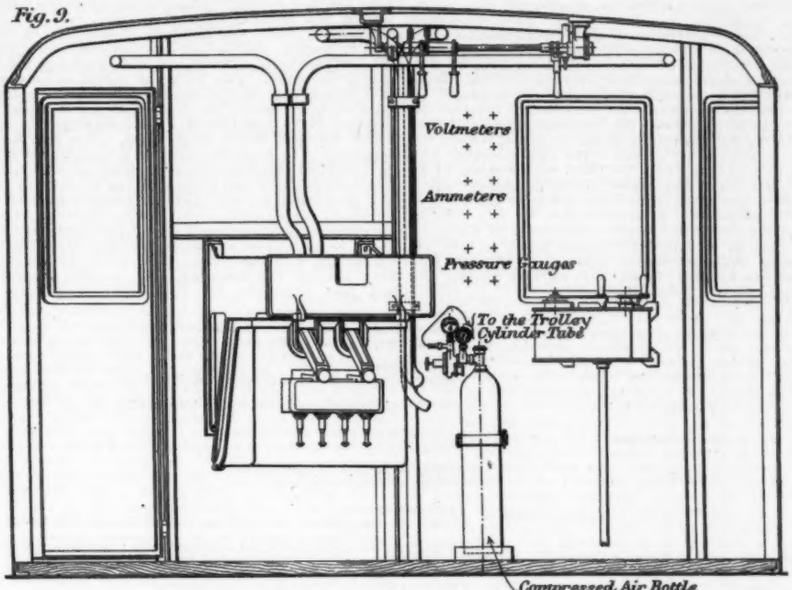
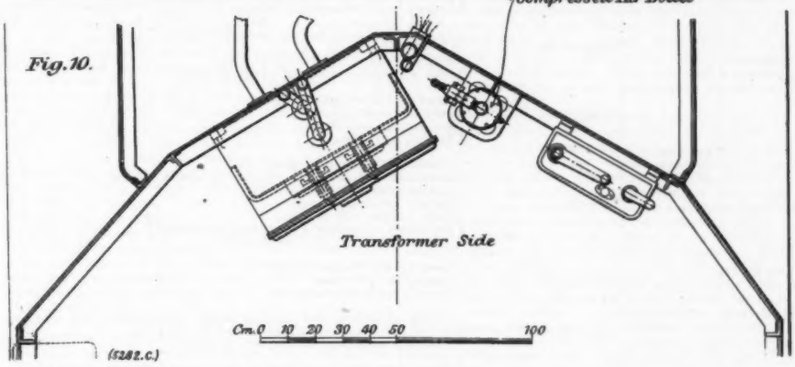


Fig. 10.



to reduce the electric pig-iron to steel on the spot. Refining the pig-iron in an electric steel furnace seems to be excluded for practical and financial reasons. The Siemens Martin process would be more suitable, as it would utilise the gas from the smelting process amounting to about 500 cubic metres with a heating value of 250 B.T.U. to 275 B.T.U. per cubic foot, and of a value under normal conditions of 2.83 sh., all per ton of pig-iron produced.

Should it be necessary to roast the lump ore (in this connection taken to constitute 50 per cent. of the whole) the cost of the plant would be increased by the price of two Westman roasting furnaces, with all the accessories, which will mean an additional outlay of some 11,000*l.* and the employment of a dozen more men. The pig-iron, thereby, will become some 0.80 sh. (interest and sinking fund) and some 1.00 sh. (wages), that is 1.8 sh., dearer per ton, and the amount of gas available for the later Martin process would be reduced to 65 per cent. to 70 per cent. of the total. That is, in value, from about 2.77 sh. to about 1.90 sh. per ton of pig-iron. It should also be pointed out that if the electric pig-iron furnace be combined with briquetting stoves, these can with advantage be heated with the furnace gas, which would further reduce the amount of gas available for other purposes.

During the refining process the pig-iron, as is well known, loses most of its carbon and silicon, as well as manganese, if such be present, at the same time as some iron is slagged. The output from the refining of the pig-iron in a Martin furnace with subsequent finishing in an electric steel furnace—which latter, be it remarked, will hardly be suitable in this case—cannot be more than 90 per cent. of the weight of the pig-iron.

In conclusion we beg to express our indebtedness and thanks for the above information to M. I. A. Leffler and the Jernkontoret, Stockholm.

DEVELOPMENTS IN ELECTRIC LOCOMOTIVES IN ITALY.

A SERIES of articles has been published in recent issues of the *Rivista Tecnica delle Ferrovie Italiane* dealing with the improvements carried out on the electric locomotives of the Italian State Railways. The Class E 550, which at first comprised only 15 electric locomotives, has gradually gained in importance and now contains 150, of which about 20 are in course of construction, the greater part being, therefore, in service. There are running, besides, 16 locomotives of Class E 330, which have many electrical parts similar in design to those of the E 550 class. Experience gained in the working of the locomotives in question, together with variations which have frequently occurred in the pressure of the current used, have led to a number of improvements in the electric equipment. The pressure first adopted, and on which the designs were based, was 3,000 volts; it rose in course of time to 3,300 volts, with oscillations up to 3,600 volts and over.

One of the appliances that suffered by the increase in current pressure was the speed regulator fitted to the traction motor and connecting it with the primary motor. The large number of contacts and the restriction of the length of the apparatus by the distance between the engine frame plates made it necessary to make the intervals between the various contacts comparatively small, and this was the case also between the end contacts and the cover of the regulator. These distances were found sufficient when the working pressure was 3,000 volts, and in normal conditions also when it rose to 3,600 volts, but when irregularity occurred in the action of the rheostat from excessive heating of the liquid due to repeated startings, or from other accidental circumstances, vibrations were set up in the speed regulator and there was a tendency to arcing between the movable and fixed contacts, the arcs propagating between the charged parts and the metallic parts of the regulator winding connected to earth, damaging the winding and leading to the disengaging of the automatic switch under short circuits. In order to prevent this inconvenience the original fixed and movable contacts have been modified; they were formerly identical with the intermediary contacts of the regulator, but have since been made similar to those on the low-tension side of the regulator, where the current is of greater volume. Moreover, the contacts have been placed somewhat closer together, so as to increase the distance between the end contact and the winding of the controller. In order, further, to prevent the formation of arcs between the contacts belonging to different phases, insulating diaphragms have been placed between them. Finally, in order to decrease the effect of the vibrations, an intermediate support has been provided. The improved regulator is illustrated in Figs. 1 to 3, page 622, which show at E the modified contacts and at F the improved supports.

The liquid rheostat of the more recent locomotives, starting from that of No. 41, is very different from that of the first 40; the original system of electrode suspension has, however, been adhered to in the main in both sets, and is illustrated in Fig. 4. Insulation between the electrodes and the metallic cover of the rheostat is provided for solely by means of small tubes of insulating material; these at first were made of micanite, and later of treated cardboard, the latter material having been selected because it is not fragile and withstands the action of the hot soda solution. The small tubes deteriorated, nevertheless, after a certain time, leading to frequent short circuits between the electrodes and the cover of the rheostat. In order to mitigate this, insulation has been increased by modifying the shape of the porcelain insulators which serve to hold the electrodes to the cover, as shown in Fig. 5. This new form has given good results, and is being gradually fitted to all the locomotives.

The automatic oil-break switches, which for several years had worked satisfactorily, commenced somewhat recently to lead to frequent fracture of the oil containers, to the disengaging under direct short circuits of the switches, and to spurts of burning oil. Chemical analyses showed that the occurrences could not be attributed to the quality of the insulating oil used; the oil, moreover, had a high flash-point (160 deg. to 162 deg.), and the only conclusion to be arrived at was that they were due to certain defects which were not at first revealed, but were later explicable by the fact that the more recent sub-stations were somewhat more powerful than the original ones, such, for example, as the one at Sampierdarena, which had become necessary owing to the extension of the electrified lines in the vicinity of Genoa. As it was not advisable, for many reasons, to increase the dimensions of the switches, attempts were made to obviate the disadvantages referred to by providing an escape for the gases through outlets at the sides of the two oil containers, between which are immersed the contacts corresponding to the two aerial current phases. The outlets are made of tubes provided with a series of baffles, so arranged that the outgoing gases have to follow a zig-zag path and tend to be extinguished in their course, whilst practically the whole of the oil is drained back inside the container. The outlets, project into the space between the containers and the casing which affords an outside protection for the switches, chimneys being provided for the gas escape, as shown in Figs. 6 to 8, in which the references are the following: A, outside casing protection; B, oil containers; C, gas outlets; D, chimneys for gas escape; E, close netting of brass gauze; F, closing device.

A switch improved as has been indicated was fitted to a locomotive, and was submitted to a succession of direct metallic short circuits whilst the locomotive, having its trolley raised up against the overhead wire, was close to a powerful sub-station. The short circuits were 11 in number, at pressures between 3,700 volts and 4,000 volts, the switches at the sub-station being gauged up to 1,200 amperes. The contacts of the locomotive switch were not adjusted during the whole of the test, and the oil was not renewed either totally or in part. When the short circuits occurred, flames were generally noticed at the switch, but they did not appear outside; there was simply an outflow of dense smoke through the gauze above referred to. The oil containers bulged out somewhat, but this led to no ultimate deterioration, whilst the contact pieces showed notable burnt patches. The oil was analysed at the close of the test; it showed but little alteration compared with its condition before the test; in regard to its insulating property, this had

decreased by about one-third compared with the original condition. A part of the oil from the containers was found after the opening of the switch to be thrown out, but none escaped outside the protective casing.

Apart from the application of the gas outlets in question, it was found advisable to provide, above the oil-level in the containers, a free space to allow for expansion. This plan is being followed in the new apparatus, whilst in the existing oil-break switches the condition is met by not filling the containers completely with oil, leaving a free space of less than 1 in. in height above the oil-level.

The raising of the current-collecting bows is normally effected by means of compressed air supplied from receivers on the locomotives. When the receivers are empty, or when the air pressure is too low, means have to be taken to renew their compressed-air supply. In some instances this is not readily effected, and it is necessary to equip the locomotive with an independent subsidiary means for supplying compressed air. The first locomotives were equipped with air pumps operated by hand, but owing to the increase in the weight of the current-collecting bows, and to the consequent increase in the presure and in the quantity of compressed air required, this means had to be abandoned in the more recent engines. These latter are now fitted with a bottle of compressed air at a pressure of 125 kg. per square centimetre (1,775 lb. per square inch), having a capacity of about 7 litres (427 cub. in.). By means of a suitable reduction valve the air is admitted, when needed, at a pressure of 4 kg. to 5 kg. per square centimetre (57 lb. to 71 lb. per square inch) into the cylinder for raising the current-collecting bow. One charge lasts approximately one month, since the occasions in which the bottle comes into use are comparatively few. An electrically driven compressor is able to charge seven bottles per hour at the above pressure. Figs. 9 and 10, page 623, show the bottle fitted to an electric locomotive.

(To be continued.)

THE SERVICE DEPARTMENT OF A SHIPYARD.*

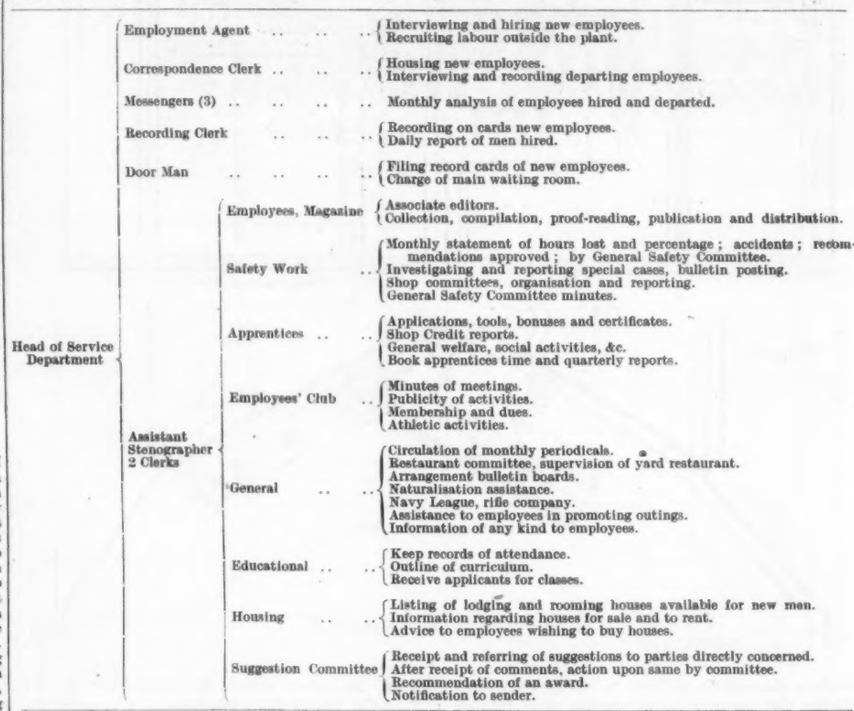
By Mr. Samuel W. Wakeman, Member.

The object of this paper is to describe a method of handling certain phases of shipyard work which has been successfully tried out in one large eastern plant. Although some of the functions of this department are probably being carried out in the different yards to-day, we do not know of anyone who has treated this problem in just this manner. About two years ago the president of the plant became interested in the enormous number of men that it was necessary to hire each month in order to maintain the working force then needed to carry out the work in hand. He determined that this problem must be solved, and a committee was selected from the plant, composed of workmen, foremen and others. They made a tour of the country, visiting the following manufacturing concerns: Link Belt Company, Sherwin Williams Company, Jeffery Manufacturing Company, Cleveland Hardware Company, Curtis Publishing Company, Chalmers Motor Company, Cleveland Foundry Company, Goodyear Tyre and Rubber Company, Cadillac Motor Company, National Cash Register Company, Dodge Motor Company, Packard Motor Company, Ford Motor Company, Westinghouse Manufacturing Company, Carnegie Steel Company. The most courteous treatment was accorded this committee at each of the above-mentioned plants, and the fullest information was given by them on all of the points which this committee investigated.

On their return they prepared a report of their investigations, together with such recommendations as to the betterment of the then existing conditions as they thought should be made, these recommendations including such ideas as the centralising of employment instead of allowing each one of the different department heads to carry this on themselves. It also recommended that a new building be erected for this purpose; that a different point of view be taken with regard to applicants for positions, namely, their treatment should be as courteous and as fair as was possible to be given; that the housing and boarding situation be investigated; that all men leaving the employ of the company should be interviewed and given a chance to air their grievances. They further recommended a great many lines of activities to be encouraged in the plant and touched on many lines that had to do with the physical, mental and social condition of the employees. The recommendations of this committee were printed in pamphlet form and sent to about 200 people in the plant. They were asked to freely criticise and, if possible, to make further recommendations. All of this information was then collected and formed the basis for the policy which is being pursued at the present time in regard to the service work in this plant.

A brick building was erected near the main gates of the plant to take care of the hospital work, the employment department, and the general activities of that nature. These activities were grouped under the name of Service Department which, as its name signifies, is to render service to the employees of the plant. This department was put under the supervision of the general superintendent of the plant. The scope of its activities are as follows:—Employment, hospital, safety work, educational work, apprentices, employees' club, works paper, suggestion committee work, yard restaurant, shop training. The *personnel* of this department consists of the following: Supervisor, assistant, clerks, stenographer, supervisor of instructors, instructors, employment agent, employment clerk, doorman, doctors, nurses, messenger boys for conducting applicants to shops.

In order to see clearly the relationship between the Service Department and the superintendents and foremen in the yard in regard to the supply of labour, the following illustration is used: The ship carpenter may want 10 pieces of 12-in. by 12-in. yellow pine, 30 ft. long. His requisition comes to the purchasing agent, who buys this material and has the same delivered to the ship carpenter. If on inspection by him three or four pieces out of the 10 prove defective, he condemns this material and the purchasing agent replaces it. The ship carpenter decides what class of work this lumber can be used for and decides also whether the price paid for it is justified.


Head of Service Department
Employment Agent
Interviewing and hiring new employees.
Recruiting labour outside the plant.
Correspondence Clerk
Housing new employees.
Interviewing and recording departing employees.
Messengers (3)
Monthly analysis of employees hired and departed.
Recording Clerk
Recording on cards new employees.
Daily report of men hired.
Door Man
Filing record cards of new employees.
Charge of main waiting room.
Assistant Stenographer 2 Clerks
Employees, Magazine
Associate editors.
Collection, compilation, proof-reading, publication and distribution.
Safety Work
Monthly statement of hours lost and percentage; accidents; recommendations approved; by General Safety Committee.
Investigating and reporting special cases, bulletin posting.
Shop committees, organisation and reporting.
General Safety Committee minutes.
Apprentices
Applications, tools, bonuses and certificates.
Shop Credit reports.
General welfare, social activities, &c.
Book apprentices time and quarterly reports.
Employees' Club
Minutes of meetings.
Publicity of activities.
Membership and dues.
Athletic activities.
General
Circulation of monthly periodicals.
Restaurant committee, supervision of yard restaurant.
Arrangement bulletin boards.
Naturalisation assistance.
Navy League, rifle company.
Assistance to employees in promoting outings.
Information of any kind to employees.
Educational
Keep records of attendance.
Outline of curriculum.
Receive applicants for classes.
Housing
Listing of lodging and rooming houses available for new men.
Information regarding houses for sale and to rent.
Advice to employees wishing to buy houses.
Suggestion Committee
Receipt and referring of suggestions to parties directly concerned.
After receipt of comments, action upon same by committee.
Recommendation of an award.
Notification to sender.

The same procedure holds for the supply of labour. A foreman finds he will need a certain number of men at a given time. He sends his requisition for this labour to the employment division of the service department. They send the required number of men to the foreman after interviewing these men and weeding out, so far as is possible, such applicants as would be incapable of carrying out the work for which they are required. These men are sent to the foreman of the department, who takes or rejects whatever number he may see fit and rates those he keeps, and those he rejects are sent back to the employment department, where an effort is made to place them in some other department in the yard where they may find work which they can do.

If the men hired are not satisfactory to the foreman, he may discharge them. In no particular are any of the foreman's prerogatives in regard to the handling of labour taken from him. The advantage of this method, however, is that the foreman is not compelled to interview a large number of men who have no qualifications for the work he is supervising, and his time is conserved for the more important duties he has to perform.

Each applicant for a position is put through a careful physical examination by the company's doctor, and only such men are employed as are capable of doing the work for which they are hired. This has resulted in getting a very good class of men, and, where slight physical defects are found which can easily be remedied, the man is sent to the proper medical authority and taken care of. At first there was considerable objection on the part of some of the men, but at the present time practically no one objects to the physical examination.

The employment department keeps an up-to-date requisition of all labour requirements of the plant, and takes such steps as are necessary, through its various sources of supply, to keep this requisition filled. It attempts to learn, by keeping in close touch with the various departments, the probable future needs for labour, which is a vitally essential factor in keeping a steady flow of men into the yard. All applicants for work are quartered in a waiting-room in the service building, equipped with chairs, and are interviewed in turn by the employment agent, being given a private interview in a separate room. Each applicant when hired is given a book which contains all the information about the plant that it is considered a new man should have. This book has been carefully prepared and gives the hours of labour, the method of tool delivery, certain safety suggestions, times and methods of payment of wages and, in general, information in a condensed form which the new employee generally gets only after long association in the plant. This book has proven to be a great help to new men coming into the plant. All employees transferred or leaving the employ of the company are required to be interviewed by the employment agent before they can obtain their wages. This provides an opportunity to place the man in a department where he may fit to better advantage than the one in which he was working, and also gives him opportunity to state any grievances he may have in connection with the company, his foreman or his work. These grievances are carefully tabulated and looked into and have been found to be a great source of valuable information in connection with controlling the feeling the employees have toward the company. All records for present and past employees are filed alphabetically in the employment bureau, and these records contain the name, age, trade physical qualifications, address, place of past employment, rate, &c. There is a daily report prepared by the employment department, showing the number of men hired and leaving by trades, also daily gain or loss in the working force. The department also makes a monthly report of the turnover of labour, including the number of men hired and leaving by trades, showing the length of service and reasons for the man leaving.

One of the most important phases of the employment work is to provide proper housing facilities, and to this end the employment department lists, for the information of all applicants, boarding houses and available houses for sale or for rent. If there is no position open at the time the applicant applies in person or by letter, an application card is filled out and filed by trades. All applications for employment are filed and, as far as possible, the applicant is informed as to what date his services will be required, giving the minimum and maximum rate for the trade desired and the hours of labour.

Under the service department is a competent surgeon and an up-to-date hospital where all of the accident cases in the yard are treated. The families of the employees may obtain free medical attention during certain hours of the day. The safety work in the plant, which had reached a fair state of development, was combined with the work of the service department and the different shop committees, together with the General Safety Committee, use this building as a meeting place, where frequent talks by men who are specialists along this line of work are given to these men. Each department has its own safety committee, which makes periodical inspections and reports directly to the General Safety Committee. A great many ideas for work of this nature have originated in these committees and numerous appliances and safeguards have been adopted, due to suggestions received from them. All accidents are carefully investigated and the causes are immediately remedied; responsibility for accidents, as far as possible is placed and steps taken to rectify them.

All of the educational work in connection with the

* Paper read before the Society of Naval Architects and Marine Engineers, in New York, November 15.

training of apprentices and the training of men in the shops and different departments throughout the yard have been placed under the jurisdiction of the service department. During the winter months, evening schools are conducted which provide training in naval architecture, mould-loft work, plumbing, coppersmith work, machine shop design, mathematics and blue-print reading. The instructors for these evening classes are, for the most part, drawn from the various departments in the yard and the instructions carried out under the direction of the local school board. These classes are open to any male beyond the age of 16 in this locality and are attended by mechanics, apprentices and helpers to the number of about 200.

All of the work in connection with the apprentices in the plant is carried out under the supervision of the foremen in the different departments, but along the lines as laid down by the educational part of the service department, and the head of this department has been very successful in this connection with the attitude of the apprentice toward the company. Each year a dinner, to which prominent officials of the company are invited, is given by the apprentices, and efforts are made to promote the best of feeling among the young men who are being trained for future service in the company.

The service department supervises the publication of a works paper, which is issued every three months by the employees. This paper has developed to such an extent that its issue is awaited with a great deal of interest by all of the men in the plant. The company presented to the employees of the plant a club house equipped with bowling alleys, rifle range, assembly and dancing hall, pool table, a band room and an athletic field where the different athletic teams practice and have their games. Quarters are provided for the athletic teams of the company in this building with suitable shower-baths, &c. This club is run entirely by the employees of the company, and only such necessary supervision is given to it by the service department as is absolutely necessary. A restaurant is maintained inside the plant for the benefit of the employees. The supervision of this restaurant, although run by an outside caterer, is left to a committee of the employees who are in close touch with the service department.

One very important part of this service department work is the handling of the suggestions sent in by employees. Boxes are placed throughout the yard, and prizes are offered for suggestions sent in by the men. There is a great deal of work in connection with the proper understanding of what the employee means, the making of sketches, the referring of these suggestions to the proper people so that they may be acted on, and the attitude which the men have toward this phase of the work must be carefully handled in order that the greatest amount of good may come from it. The work of this committee, of which the head of the service department is chairman, is one of the very important functions of this department.

All of this work has begun to show results which it is felt can directly be traced to the work of this department. Statistics for many of the large manufacturing plants throughout the country that have attempted to increase their working force have shown that it is necessary to hire anywhere from seven to ten men in order to obtain one permanent employee. The latest results here have shown that it has been necessary to hire two men instead of from seven to ten in order to obtain one. When you consider that it is estimated that it costs somewhere between 20 dols. and 35 dols. to hire a new employee the result of cutting down the turnover in any plant means a tremendous saving in dollars and cents, although it may not always be possible to measure this directly. Much of the reason for this decrease in turnover can be credited to the selection on the part of the service department; the hearty co-operation of the foremen, who have allowed a very liberal system of transfer from one department to another; the training of men into trades which they were not familiar with and, in the main, to the general broad policy of the man directing the company.

Before the above plan was in operation, in order to maintain a force of about 4,000 employees it was found necessary to hire, in the course of a year, 8,000 men. During the last six months the present force has been increased from 4,000 to 8,000, and this has been done by hiring 9,000 men. While these results cannot all be attributed to the work of this department, nevertheless it is felt that, in a large measure, the work which has been accomplished by them is responsible for a large percentage of this showing.

It is not claimed that any new or radical ideas have been adopted in connection with the handling of this situation, but what has been done is to find out what successful concerns in other lines of work have done, and to combine them together in such a way that they might be adapted to the work of a shipyard. A man was employed who was thoroughly familiar with the sources of labour supply in the district in which this plant is located, and much credit is due him for the enthusiasm with which he approached this difficult problem. An outline diagram showing the relationship of the different functions of this department to each other is given in the preceding page.

THE ORIGIN OF THE 4-FT. 8½-IN. RAILWAY GAUGE.—The present railway gauge was due to the accident of circumstance, says *American Machinist*, New York. It was at first 5 ft., measured between the flanges, which were on the outside of the rails. When the flanges were placed on the wheels in order to serve existing cars, the gauge was reduced to 4 ft. 8½ in., where it now stands. Unfortunate as this is, there is no better illustration in the entire range of industry of a dimension which it is impossible to change.

THE INFLUENCE OF THE WAR ON SUBMARINE POLICY.*

By MARLEY F. HAY, Member.

THE outbreak of war in August, 1914, found the supreme naval power, Great Britain, in possession of the numerically strongest submarine fleet. It comprised about 90 vessels ranging, with a few experimental exceptions, from 200 tons to 800 tons in displacement. The submarine at that time was admittedly and manifestly the weapon of the weaker power, inasmuch as it was presumably a weapon pre-eminently of defence, and it was hardly deemed politic for secondary or lesser powers to entertain aggressive national policies. Moreover, the tremendous pecuniary burdens involved in the acquisition and maintenance of a fleet of capital ships reduced this policy of defence to a policy of necessity. So conclusively is this the case that certain of the smaller powers have conceded the principle that, militarily speaking, submarines should form the major part of their fleet, with only a certain number of destroyers and auxiliaries as supports.

While the principle has been fully recognised in theory, a subtle but powerful consideration has tended to prevent its full implementation in practice, namely, the service or *personnel* necessity for large ships. An exclusively submarine navy would provide no sea commands for officers who had passed their thirtieth or thirty-fifth year, so that large ships have been incorporated in the fleet if for no other purpose than to provide higher commands for older officers and to offer sufficient incentive for young men to enter the naval service, without which prospect the ranks of the Naval Academy would have been hopelessly depleted. This has constituted the principal motivation for large ships in certain concrete instances. During the nineteenth century, Great Britain has occupied the position of supreme naval power, hence all other powers have been comparatively and relatively in the position of navally weaker powers. The logical result of this status should have caused the British Admiralty to discourage early efforts to establish the practicability of the submarine, and that the situation was thus appreciated is evidenced by the fact that Robert Fulton, the American inventor of an early type of submarine, was offered substantial remuneration by the Admiralty for the entire suppression of his patents and ideas. This occurred a century ago, after his failure to obtain recognition in America and France.

In 1914 Great Britain's numerical superiority in submarines was probably attributable to a belief in the suitability of submarines for coast and harbour defence, which had, in fact, been amply demonstrated by their success in the naval manœuvres of the preceding five years. The utilisation of submarines for coast and harbour defence naturally released a certain part of their fleet for other and possibly more important work.

In a consideration of the effect of the war upon submarine policy, we are immediately concerned with the principal belligerents, and especially the central empires whose sea policy has brought submarines into such prominence. On the allied side, France entered the world conflict with a heterogeneous assemblage of submarines, about fifty in number, with the widest range of variation, both in regard to displacement and military characteristics. The Russian submarine flotilla has played a very inconspicuous rôle in the operations that have taken place hitherto and can hardly be said to have influenced submarine policy, either technically or strategically. By and large, the same may be said of the other allied powers, and the comparatively late entrance of the United States as a belligerent, if nothing else, would account for the inactivity of American submarines as far as the major naval operations in the North Sea and in the waters surrounding the British Isles are concerned.

It may fairly be assumed, however, that since April last this country has profited at least potentially by the previous war experience of the Western allies. Paradoxical as it may seem in the light of later developments, the last of the great powers to admit the desirability of or necessity for submarines was Germany, and that conclusion was only reached under the pressure of actual war, when it was manifest that the rest of her fleet was of practically no use. If one believes that the German Government has been preparing for many years in anticipation of the present war, it seems incredible, in view of the completeness of her preparedness in all other respects that the submarine arm of the naval service was neglected and discredited up to the day that war broke out. It was assuredly an oversight on the part of the German authorities, for in several conversations the writer had with Admiral von Tirpitz in 1911 in regard to Germany's submarine policy, the latter expressed emphatically as his opinion that he considered submarines to be in an experimental stage, of doubtful utility, and that the German Government was not at all convinced that they would form an essential or conspicuous part of their future naval programmes. This opinion, which undoubtedly incorporated the opinion of his principal subordinates, was not expressed with any purpose of misleading, for it was a well-known fact at the time to every one in the profession that Germany's position in the matter of submarines was that of a third-class power.

When hostilities commenced Germany had 25 submarines in commission, and was building perhaps half-a-dozen more. They were all of the Krupp-Germania type, and von Tirpitz explained almost apologetically that they had built a few just to be able to form some conclusions regarding them based on their own experience. It was evident at that time, however, that no great thought or attention was being devoted to their development—nor were ideas from outside sought.

Any casual student of European politics during the last fifteen years knows that in every international complication that arose and threatened European peace Germany was always to be found on one side and England on the other side as potential antagonists. If Germany had foreseen every contingency and provided for it in advance, she must necessarily have regarded the participation of England as an adversary in the present conflict, or, in fact, in any conflict in which Germany was involved, as a possibility at least, even if a remote one, and she must also have foreseen that the participation of England would bring about the enforced inactivity of the German high-sea fleet.

She could also have foreseen the situation that now prevails, *i.e.*, the submarine branch of her naval service would be the only one that could deliver any effective blows against England. Under these circumstances, how is it possible to explain the utter failure of the German Government to comprehend, or, if they comprehend, to provide for the rôle that submarines are playing to-day? Is it possible the General Staff and the Reichs Marine-amt refused to recognise the possibility of England's participation as even a remote contingency, and that no appropriate preparation was made to meet it? It would almost seem so, for when England definitely entered into the conflict against Germany steps were taken in feverish haste to lay down over 60 submarines at once, and that number has since been largely augmented.

Estimates have appeared in print according to which Germany was credited with having over 700 submarines in her possession last May and that 1,200 would be in commission by the end of this year. It can hardly be possible that such an estimate has been made by any person familiar with the shipbuilding facilities of Germany, even making all due allowance for abnormal expansion of these facilities to meet the necessities of the occasion. It has been stated that dry docks would even be utilised for the purpose of erecting them, as if the problem were primarily one of ground space.

The entire shipbuilding capacity of Germany is very limited, compared with England, for instance, and the difficulty of finding highly trained and skilled shipbuilding labour, such as is required for the intricate work of constructing a submarine, would militate heavily against any sudden increase in the tonnage that could be turned out. Taking into account all the shipbuilding facilities of Germany, both private and governmental, making the most liberal allowance for the maximum extension of these facilities under pressure of war, bearing in mind at the same time the difficulty experienced in obtaining certain necessary machinery and appliances and in obtaining skilled labour, and deducting the number of submarines that have probably been lost or destroyed by the enemy, it does not seem possible that Germany had more than 200 submarines in commission last May. Of this number approximately two-thirds would be constantly available for duty, while the other one-third would be *en route* either to or from the various shore bases for the replenishment of supplies and for repairs.

To arrive at a fair or accurate estimate of the rate at which Germany can build submarines in the future is somewhat more difficult. Assuming, however, that all yards in the country were utilised exclusively for this kind of work, and that no mercantile shipbuilding or repairs to the battle fleet were undertaken, which, of course, is far from being the case, the probability is that not more than 100 submarines could be completed every six months. Information at hand would indicate that the actual recent output has been approximately 10 per month, of which the great majority are in the neighbourhood of 800 tons to 1,000 tons displacement. Several groups of about 1,500 tons have also been commissioned, and quite recently the construction of a flotilla of 8 so-called submarine cruisers of 2,800 tons displacement has been undertaken, of which 3 or more are reported completed and the remainder will be ready for service by next February. These vessels will mount two 6-in. guns, besides two guns of lighter calibre, and embody the innovation of an armoured conning-tower. This is more or less essential where the conning-tower constitutes the central control station of the vessel and at the same time is the most vulnerable part. It is only feasible, however, on vessels of great size, because of submerged stability considerations.

All the later Austrian submarines have been manufactured in Fiume and Trieste from German plans, and constitute, in effect, a German submarine flotilla in the Mediterranean that has avoided the necessity of the hazardous journey from the North Sea through the Straits of Gibraltar. Turkey and Bulgaria have not been contributory factors in the submarine plan of campaign. The effect of the war on the submarine policy of Germany has manifested itself in a tremendous programme of acceleration and access of numerical strength with increase in displacement and radius of action, as hereinbefore indicated, to meet the exigencies of long cruises off the West Coast of the British Isles, necessitated by the effectual closure of the English Channel.

It is not at all clear that before the war any of the allied powers, or for that matter the central powers, seriously anticipated or contemplated the possibility of ruthless submarine tactics against merchant shipping as at present employed by Germany. Nevertheless, some years before the war there was a lively discussion in the British press of certain alarmist literature, notably a book by Sir A. Conan Doyle, in which ruthless submarine warfare at its worst against merchant and passenger vessels was portrayed with grim accuracy. It was generally, if uncomfortably, dismissed as

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* Abstract of paper read at the meeting of the Society of Naval Architects and Marine Engineers, in New York, November 16.

grotesquely fantastic with, at the same time, a secret hope that eventual enemies might fail to apprehend the pregnancy of the suggestion. The initiation of the sinking-on-sight policy was justified by its authors as another of those convenient "military necessities," the results of which would sanction its utilisation.

That it was not a predetermined policy before the outbreak of war appears to be evidenced by the fact of Germany's complete unpreparedness at that time to conduct submarine warfare, coupled with the further fact that the design of the earlier German submarines indicated the intention of anti-warship rather than anti-merchantman tactics. Be that as it may, when the German submarine campaign was finally launched against the Allies in all its ferocity, academic questions regarding the presumptive policy of its inception had to give way to the physical fact of its reality and the necessity of counteracting it by every possible means. At a very early stage in the war, certain important areas were defended by a series of nets with various devices to indicate the presence of a submarine in the net, and so aid in its capture or destruction. Large numbers of high-speed patrol launches mounting a 2-in. or 3-in. gun were employed to hunt and shoot down exposed conning-towers or hulls, and destroyers were rapidly fitted with emergency rams to permit them to charge submarines on sight with a fair chance of success without undue damage to themselves.

The immediate effect of these tactics on the part of the Allies produced the counter measures of knife-edges and net cutters at the bow to facilitate penetration of the net, clearing lines and similar devices protecting all projecting parts to the same end, and housing periscopes to bring the top lenses in the housed position, below the clearing lines.

The larger submarines then under construction increased their armament to guns of 4-in. calibre to outrange the patrol boats, and the latest vessels with 6-in. guns are formidable opponents of a destroyer. The danger of ramming induced a radical increase in the length of the periscopes up to about 10 m. in some of the latest boats. By this means it is possible to keep a look-out in fairly rough weather with several feet of periscope exposed, and at the same time maintain a sufficient depth of water above the vessel herself practically to preclude the possibility of successfully ramming. The conning-tower remains as the only vulnerable part in this condition, and the destruction of the tower, while serious enough, by no means entails the loss of the boat.

To reduce resistance to propulsion submerged and at the same time obtain sufficient rigidity in the free portion of the periscope above the highest bearing, the use of these extremely long periscopes has necessitated an increase of the housing distance to the greatest practicable degree, the eyepiece in some cases being almost in the bottom of the boat when the periscope is fully housed.

The ubiquity of vigilant patrols and destroyers has necessitated on both sides a revised conception of quick transition from the surface condition to the submerged condition, whether statically or dynamically. The necessary sequence of operations to bring about this transition, which in time of peace was customarily performed consecutively, is now perforce executed simultaneously, and any practical expedient by which seconds may be saved is unhesitatingly adopted. Upon a given signal the engines are stopped, exhaust pipes closed, clutch to main shaft disengaged, conning-tower hatch closed, ventilators closed down, motors started, kingston valves and vents for flooding main ballast tanks opened and the crew all stand by at battle stations.

To expedite still further this manœuvre the allied submarines navigate frequently with open kingstons, depending upon air pressure in the ballast tanks to regulate the ingress of water. The Germans, on the other hand, maintain a partial vacuum in the empty ballast tanks, which in effect approximately doubles the head of water. As the tanks must, in the nature of the case, be filled while the vessel is still on the surface, the head of water can never exceed the draught of the vessel, and even this comparatively low head is steadily reduced by the filling of the tank. With a given total area of kingston valves, the increased rapidity with which the water will flood a tank containing a partial vacuum instead of air at atmospheric pressure will be apparent. The usual vent pipes to permit the escape of air from the tanks are also fitted, and these are opened as soon as the vacuum gauge on the tanks indicates the re-establishment of atmospheric pressure. The partial vacuum in the tanks is obtained by pumping out the air with the usual high-pressure air compressors that are installed for air service purposes.

The system is open to the objection that an emergency might arise demanding quick submergence shortly after a previous emergence and, before sufficient time has elapsed, to produce under-pressure in the tanks. As the time required is comparatively short, however, and even a few inches of vacuum are effective in increasing the rapidity of flow, this disadvantage is relatively insignificant.

At an early stage it was apparent to the German authorities that the expenditure of 20-in. or 18-in. torpedoes on merchant ships represented wasted energy: moreover, the number of tubes and torpedoes of that size that a vessel could carry was relatively limited. At the same time, the general policy of defensively arming merchant ships militated against the German practice of coming to the surface and leisurely sinking the victim with a few inexpensive bombs placed on board or several well-directed shots from the gun, for which 200 rounds to 300 rounds of ammunition could be stowed.

These considerations, taken in conjunction, indicated the desirability of evolving a new type of small torpedo proportionate to the work to be done, of which a larger number could be carried on board than would be possible with 18-in. or 20-in. torpedoes within equal limitations of weight and space. This led to the adoption of the 14-in. torpedo and permitted the installation of approximately twice as many tubes and torpedoes in a given design.

The experience of the war has taught submarine officers to make the most of the virtue of invisibility; showing more than the top of a periscope during the 20 hours of daylight in the summer months is an undue risk not to be taken without sufficient reason. The energy of the battery must be conserved, however, to be available when needed in an emergency. To that end arrangements have been perfected to facilitate what is variously known as balancing, statical diving or suspending. With a minimum expenditure of power, the vessel remains stationary in the submerged condition with only the tops of the fully-extended periscopes exposed. With the sensitive listening devices now extant it is of vital importance that this mechanism be as nearly noiseless as possible and that no air bubbles escape to betray the presence of the boat. By housing the periscopes during this manœuvre, nothing is visible above the surface of the water. This plan is sometimes employed when close pressed to elude pursuit when the depth of water is too great to permit descent to the bottom.

Another method of economising battery energy frequently resorted to consists in navigating the vessel with the ballast tanks full and ready for diving under the Diesel engine. The only exposed portion in this condition is the conning-tower fairwater, and that is not a measure of the actual reserve buoyancy, for the apparent freeboard is due to the dynamic effect of propelling the vessel forward in this condition with the stern diving rudders set slightly to rise. The hatches all being closed, the air for the engine is supplied by a quick-closing ventilator.

This operation was regarded dubiously before the war, but its success has justified its wide adoption, so that what was once considered a precarious expedient has now become commonplace routine. Doubts were felt regarding the possible effect on the crew of a sudden inadvertent closure of the ventilator supplying air to the engines and a consequent rapid drop in internal pressure. In practice the effect on the crew is nil, other than a momentarily disagreeable numb sensation in the ear drums.

The use of nets in this war as a defence against submarines and the desirability of evading these entanglements by diving below them will probably lead in course of time, if it has not already done so, to the consideration of increasing the strength of the pressure hull to make submergence to a depth of 300 ft. or 400 ft. a practical possibility, instead of the working limit of 200 ft. that generally obtains to-day. To accomplish this result a certain rather serious sacrifice of other military qualities will be, of course, inevitable.

"Daily Mail Year Book, 1918."—We have received a copy of this year book for the coming year. It is edited by Mr. David Williamson and is issued at the price of 9*d.* by the Associated Newspapers, Limited, Carmelite House, E.C. It contains a large number of interesting articles dealing mainly with the war, among which we may cite, at random, "Engineering in 1917," "Air Power," "Submarines and the War," "Cruises of the Submarines," &c. It forms a very complete compendium of events during the present year, reference to which is facilitated by a detailed index.

The Late Mr. Wm. M. Urie.—We regret to learn of the death, at his residence, "Ferndale," Bishopbriggs, Scotland, on the 9th inst., of Mr. William M. Urie, who resigned some time ago the position of Works Manager of the Caledonian Railway Company's Works at St. Rollox, a position he held for very many years. Mr. Urie, who was born in 1850, received his education at the St. Enoch's School and Training College, Glasgow, and served six years' apprenticeship in the Hyde Park Locomotive Works and the Glasgow Locomotive Works. From 1870 he sought to widen his knowledge of engineering by serving as a mechanic in several works, including the Fairfield Works of John Elder and Co., the Bowershall Works of Leith, Palmer's Works at Jarrow, and the Gorton Foundry, Manchester. He then proceeded to a position in the Belgian Locomotive Works at Brussels, where for a time he served as draughtsman, and later went to Gouin's Locomotive Works at Paris, returning to Brussels as draughtsman. The five years thus spent gave him a wide knowledge of general mechanical practice, which was reflected in this later locomotive work. For eight years, from 1875, he was draughtsman of the North British Railway Company's Works at Glasgow, and for some time afterwards occupied a high position in the Caledonian Railway Company's Works at Glasgow. For the next four years he was manager and engineer of the Steam Tramway Company at Singapore. Returning to Glasgow, he served for a time as assistant to Mr. John Strain, M.Inst.C.E., and in 1889 went as draughtsman (immediately afterwards becoming chief draughtsman) at the Caledonian Railway Works at St. Rollox. He later became works manager and from this time forward was a close co-adjutor and personal friend of Mr. M'Intosh in his many successive improvements in locomotive designs. He retired from this position about the time when Mr. M'Intosh also ceased his long connection with the Caledonian Railway. Mr. Urie became a member of the Institution of Mechanical Engineers in 1899, and many engineers who enjoyed his friendship and recognised his great personal worth, as well as his sound knowledge in mechanical engineering, will share our regret at his death.

WORM GEARING.

To the Editor of Engineering.

Sir,—Mr. Pettingill, in his further remarks on the above subject, published on page 599 of your issue of the 7th inst., seems to think that I have overlooked the effect on the velocity of rubbing due to the backward rotation of the lower surface CD. This is not so: the backward rotation is equal to EF as indicated by the new position C′D′, hence FE′ clearly indicates the amount of rubbing which takes place.

Mr. Pettingill seems also to be under the impression that the surface CD has rotation other than indicated in the diagram, which appears to be substantiated by his regarding it as part of the grindstone. As previously mentioned the full motion of CD is represented by the line EF, so that his supposition and deduction is incorrect.

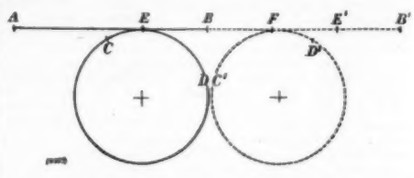
Yours faithfully,
Francis J. Bostock.

Park Works, Lockwood, Huddersfield.
December 11, 1917.

To the Editor of Engineering.

Sir,—With reference to the correspondence now running on "Worm Gearing."

The matter seems to have boiled down to a discussion on the diagram given in your issue for December 7, and which Mr. Pettingill pertinently compares with a "grindstone" working on (the surface of) a "drawing board."



May I ask that this diagram be again repeated, with the trifling addition of the completion of the circles with their centres X and X_1.

It appears—to a non-partizan reader—that the matter might be brought to a head by admitting that Mr. Bostock is right in saying that his point E in moving along the line to E_1 may have a rubbing friction represented by F — — E_1, against the "grindstone," if the latter—in the same time—has a motion of translation as a whole from X to X_1, without any necessity for revolving "backwards," nor, for the matter of that, forwards either.

Yours faithfully,
"M.I.Mech.E."

Experimental "S," Mining School, H.M. Gun Wharf, Portsmouth, December 11, 1917.

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—I think the sweeping statement of your correspondent "Waiting," to the effect that the average wage of a draughtsman before the war was about the same as that of an ordinary workman (which I take to mean a fitter or turner at, say, 35*s.* to 40*s.* per week) should not be allowed to pass without challenge. To an outside reader such a statement is calculated to give quite an erroneous impression as to the status of draughtsmen in general.

I am aware that there are some mechanical draughtsmen—mechanical in a double sense—to whom the above may apply, and also juniors who have not yet reached sufficient proficiency to obtain the current rates, but speaking with twenty years drawing-office experience, I venture to say that no competent draughtsman need work for such a miserable salary, and if he does, then he gets what he deserves, and, moreover, in doing so he is helping to keep the general rate of remuneration at a low level.

However, my experience is that a good man can generally command a good wage, as draughtsmen's wages go. By this I do not mean to imply that draughtsmen are paid as well as they should be, but at the same time I think the majority of them would not care to have their vocation placed on a par with that of fitters and turners, &c. I agree that draughtsmen have been badly treated with regard to remuneration since the war, but that does not affect the point raised which refers to the pre-war status.

"Waiting" seems also to rather sneer at the terms "status" and "profession" as concerning draughtsmen, but along with many others of your correspondents, I maintain that for a properly qualified man they are quite as applicable as in the case of, say, a doctor or lawyer. For the same reason I also believe that to bring the profession down to the level of a trades union by amalgamating with the Amalgamated Society of Engineers would be a retrograde step, and would certainly lower the general status.

I am, yours truly,
"Forward."

December 5, 1917.

WAKE UP ENGLAND.

To the Editor of Engineering.

Sir,—There are many, I am sure, among the employed as well as the employing classes who are concerned as to whither the ever-increasing higher wages, combined with low and restricted output are leading.

It is agreed, I suppose, by all thoughtful people, that

the present high level of wages is in the best interest of the community, and also, speaking generally, that this high level must be supported after the war. But, and this should be very distinctly understood, high wages can only survive when allied with high production. The restricted and "happy-go-lucky" methods employed in this country must be abandoned. If not, the end will be national disaster; we shall be unable to compete with America and Germany in the markets of the world.

This war has been fortunate for this country, in the sense that it has clearly shown that we, as an industrial nation, were decadent. We were hide-bound with old and obsolete traditions; living on a reputation we had failed to uphold. Take for example the Sheffield cutlery trade. Twenty years ago we were unrivalled. By 1914 this trade had practically all gone to Germany. Why? Because the workers would not accept new machinery and methods, and the masters could not realise the value of such. They were content to work with the same tools that had been used for eighty years past; consequently Germany captured the trade without an effort.

Our methods, machinery and buildings are out of date. We begrudge the money necessary to pay for educating and training our young engineers, who could, had they this training, steer the British ship of industry, safely through the difficult shoals of competition. Leading industrial engineers in America have stated that high efficiency in the workman is of no value unless he is properly directed.

This is realised to the extent that manufacturers in that country are willing to contribute generously to maintain training centres, so that their young men may be trained to become successful leaders. In England we are waiting and hoping that the Government will take this matter over, and in thus waiting are being left in the race for supremacy.

The successful industrial leaders of this country can be counted on the fingers of one hand; books on engineering management are all American; piece-work systems are with one exception American. In the past forty years we have not contributed any great invention for the world's use; in other countries this period has been noted for its inventions.

Statistics prove that the American workman produces from two to four times as much as his *vis-à-vis* in this country. This is, no doubt, due to the more efficient direction of his efforts, better machinery and working conditions. On the other hand, it must be admitted that the American workman runs his machine to its full capacity. He is the highest paid worker of any country; at the same time his production capacity is second to none. They have their strikes, but when a decision has been agreed upon, they show themselves ready to abide by and honour such decision.

Again, one of the secrets of success is mass production, of which we in this country know very little, or if we do know, have failed to take advantage of. Instance the great motor-car concerns in America, whose success is truly phenomenal. What is the reason for this success? There are three; mass production is the base. But how to attain production on such a large scale, and where is the market for same?

Firstly, the American firms work on scientific principles. An unnecessary hammer tap or pass of the file is taboo. Highly-paid engineers are scheming day in and day out, short cuts in methods and machinery, to accelerate and cheapen production.

Secondly, the workman is given a square deal. There is no such thing as a cut in piece-work prices. The more a man earns the better pleased are his employers, as they realise he is also earning more for the firm. Here, however, it should be pointed out that rates are fixed with much greater care and on a more scientific basis than in England. The workman, also, is quite reasonable in granting facilities to the rate-fixer to enable him to set a fair rate; the worker will actually hold the stop watch, whereas in this country the sight of one means a strike.

Thus in America the piece-rate is set on substantial grounds and cuts are unnecessary. Unreasonableness on the part of the British worker, and inefficient rate-fixers, operate against a fair rate being set, consequently mistakes are common, and it is useless to say that such mistakes should not be corrected. There is, however, no doubt, that employers in this country have earned an unenviable notoriety, by their shortsighted principle of cutting a rate whenever a workman, by dint of hard and efficient labour, earns more than a certain sum. Such persons are a danger to themselves and to the community.

It should be mentioned that rate-fixers on the Continent are paid three to four times as much as men in similar positions, on this side. If the status here was raised, a better class of men would be attracted and rates would be set more agreeable to both parties. The American draughtsman and designer receives twice as much as his English namesake. The American production engineer has unlimited opportunity for advancement; in this country he is a fixture.

Thirdly, the Americans are content to sell at a small profit, spares at practically cost price. By so doing they create a market where otherwise there would not be any.

It will be easily imagined that a man with, say, 150*l.*, could be persuaded to purchase a car at that price, whereas nothing would tempt him to pay 250*l.* Similarly, many people are tempted, and strive to obtain one at so low a price. English manufacturers are not content with small profits, anything but, thereby confining themselves to a small market. Now as a small market means a small production, so the latter means high manufacturing costs, therefore we are simply cutting our own throats and trade goes elsewhere. It would be safe to say that an article that could be made in this country for 50*l.* would have a selling price of not less than 200*l.*

Undoubtedly we must design our machinery on mass production principles. This means a design wherein the limits or tolerances will be wide, an aspect very often not considered. We must standardise our units. Thus a headstock, or an apron, or a feed-box, will fit many types of machines and also many makes of machines; similarly, pistons, crossheads, steering gears, differentials, &c.

We must not, when producing a new design, rush the same on the market, nor must we rush the designing. Give the design a thorough try out under all conditions. Have the opinion of our best engineers; then, when we are satisfied that from a service and also a production viewpoint, it cannot be bettered, place the order for as large quantities as possible. Don't make alterations to design simply for novelty, as we are so fond of doing in this country. Naturally, mass production mitigates against improvements, but very often these latter are, at best, doubtful, or only slight, and not worth making, as they greatly disturb the factory organisation and are expensive.

Standardise, standardise, and again standardise. That is the key to success.

We must study foreign requirements, and build to suit same; a feature very often neglected. We must exchange trade secrets, and mutually help each other. We must establish banking facilities on the lines of Germany and America, so that longer credit can be given and also foreign markets exploited. We must persuade our young representatives and travellers that to the successful, both at home and abroad, the possibilities are unlimited. The best persuasion is *l. s. d.* Only in this manner shall we get the best from the best men.

Finally, we must break down the class distinction between masters and men, so common in this country. In this way a better understanding will be established. Strikes will be less common. Differences can be adjusted on the spot, before they have time to assume large dimensions. The clouds of suspicion, now all too prevalent, can thus be dispersed and a well balanced feeling of mutual goodwill and helpfulness established.

Yours faithfully,

H. KAY.

15, Elmsmere-road, Didsbury, near Manchester.

THE MILITARY AUTHORITIES AND ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—At frequent intervals your Journal has remarked on the discouraging attitude of the military authorities towards the civil engineering profession in general, but you are probably unaware that, even after the acceptance of his services as a specialist army officer, the civil-trained engineer is continuously dogged by this lack of appreciation throughout his army career. The fact is, however, indisputably demonstrated by a simple comparison between the three specialist branches whose officers are obtained from the members of respective civilian professions, thus:—

Officers of the Army Medical Services are drawn from the medical profession, after the usual civil training necessary for professional qualification.

Officers of the Army Veterinary Services are drawn from the veterinary profession in like manner.

Similarly, the engineering, architectural and surveying professions are represented in the army by the "Staff for Royal Engineer Services," a body of specialist officers drawn from these professions after due training and qualification by examination in civil practice.

During their studentship days and while in civil life, these several individuals enjoy equal social and professional status, and it is only after joining the Army Forces that the technical officer slowly finds himself "out in the cold." For the doctor and the "vet." are, without hesitation, granted "substantive" army rank and a scale of rapid promotion placing them on terms of full equality with all other army officers. In contra-distinction, the S.R.E.S. officer is unceremoniously relegated into "honorary" rank (the only officer from the professions so treated), and his scale of promotion has been deliberately planned to leave him in a relatively inferior position so long as he remains in the Service.

Anyone acquainted with army sentiment will appreciate the peculiar subtle class distinction between substantive rank and honorary rank, and it is only when too late to retract that the unsuspecting S.R.E.S. officer wakes up to the fact that the diploma from his professional Institution has not saved him from the ignominy of extreme "unprofessional treatment."

Substantive rank is by no means a reservation for combatant branches only. It is granted to doctors, paymasters, "vets.," stores officers, railway officers, graves registrars, financial advisers, and other purely non-combatant officers, and it is surely the duty of the technical institutions to see that their members in the S.R.E.S. are no longer left on a lower plane.

As regards promotion, while the doctor and the "vet." become lieutenant-colonels at sixteen and twenty years' service respectively, the majority of the S.R.E.S. officers cannot hope to reach the same rank with less than about thirty-seven years' service. Whereas the doctors can ultimately become surgeon-generals and the "vets.," paymasters and ordnance officers can become major-generals and brigadier-generals, the S.R.E.S. officers are debarred from any rank higher than that of lieutenant-colonel.

The peculiar differentiation is deeply humiliating and interferes with an officer's duties on every hand. Up to the present the "powers that be" have been unable to produce any reason for it, but so long as the technical institutions allow it to exist military circles cannot be expected to hold a high opinion of the professions they represent.

The journal *Truth*, in noting that many S.R.E.S. officers have, during the war, been working "cheek by jowl with combatant R.E. officers in the field," has given a straight opinion that it is time the technical institutions followed the footsteps of the medical associations in looking after the interests of their army members. A somewhat belated move by a certain Institute has received the usual official rebuff, but so far, I gather, the Institution of Civil Engineers has done nothing to protect its members from an intolerable situation.

The writer can definitely state, without fear of contradiction, that such unprofessional treatment to a body of army doctors would not be permitted by the medical associations and would certainly raise a storm of indignation from the whole medical profession. In like manner, will not our professional brothers urge their Institutions to remove what is nothing less than a deliberate slur on the technical professions, by claiming for the S.R.E.S. officer a status equal to that given to all officers from other professions.

This equal status involves no cost whatever to the public. It simply means granting the following: All officers of the S.R.E.S. to have substantive rank and to be automatically lieutenant-colonels at twenty years' service, the senior officer of the S.R.E.S. to be brigadier-general, and the next eight in seniority to be colonels. Not an extravagant concession considering the other branches, as instance: Army Ordnance Department with three major-generals and seven brigadier-generals, Army Veterinary Service with one major-general and four brigadier-generals, Army Pay Department with two brigadier-generals, &c., &c.

Yours faithfully,

"SUUM CUIQUE TRIBUTO."

November, 1917.

P.S.—If there is a shadow of fact in the letter on page 219 of *Truth*, No. 2,123, of August 15, 1917, as to persons deemed fit for substantive rank as temporary officers in the Veterinary Service, you can imagine the feelings of the expert officer of the S.R.E.S. to whom such rank is still denied.

REFRACTORY PROPERTIES OF MAGNESIA.—Following up their experiments on clay bricks and on silica bricks, Henry Le Chatelier and B. Bogitch (*Comptes Rendus*, October 15 1717, pages 488 to 491) examined the strengths of magnesia bricks at high temperatures. Pure magnesia, they say, melts at 2,400 deg. C. (authorities differ); but commercial magnesia always contains iron carbonate, silica, alumina, &c., and these impurities melt at lower temperatures and form a soft magma, in which the magnesia particles float, so that the strength is much decreased. Attempts made in the laboratory to prepare a block of pure magnesia by fusing precipitated magnesia in an electric furnace, were only partly successful, because the lime of the furnace walls volatilised and contaminated the magnesia. This brick contained 94 per cent. of MgO, while a brick from Styria (S) contained 86.7 per cent., and one from Euboea (E) 93.4 per cent. In the test the E brick turned out strongest. All the bricks began to fail at some temperature, when the strength dropped from about 420 kg. (E) and 150 kg. per square centimetre (S) to almost zero. This temperature was between 1,500 deg. and 1,600 deg. C. for the E brick, and between 1,300 deg. and 1,400 deg. for the S brick. A ferro-chrome brick (50 per cent. chromium oxide, 15.5 per cent. iron oxide, 12.3 per cent. magnesia, the rest alumina, lime, silica and manganese) failed already at 1,100 deg. C. Magnesia bricks are thus not suited for high-temperature furnace arches.

DEPOSITION OF SILVER ON GLASS.—In the chemical deposition of silver on glass use is made of silver nitrate, which is precipitated with ammonia and redissolved in an excess of ammonia, and further, of various reducing agents which to a certain extent check one another, so that with several of these agents better results are obtained than with one alone. The reagents in question are tartaric acid or alkali tartrates, formaldehyde and several sugars (milk, fruit, cane sugar). The concentration and temperature of these reagents much influence the quality and adhesion of the deposits, as well as the rate of deposition. Studying these relations in a paper brought before the American Chemical Society last September, A. Silverman and R. M. Howe find that tartaric acid is preferable to potassium tartrate, that cane sugar is as efficient as the more expensive other sugars, and that suitable solutions can be prepared for working at ordinary temperature; when the deposition is effected from a hot solution, there is danger of peeling since the silver and the glass have not the same expansion coefficients. In some cases, notably with formaldehyde, they noticed that the metal was deposited in spots—a fact mentioned by Liebig already; this happened particularly in summer, and they avoided the spots by cooling the solutions with ice; but alcohol proved a more convenient controlling agent. For rapid deposition in the cold (i.e., at ordinary temperature) Silverman and Howe recommend the following solution: 20 cub. cm. of 0.2 molar silver nitrate solution are mixed with 0.5 cub. cm. of methyl alcohol (80 per cent.), to which 0.5 cub. cm. of formaldehyde (50 per cent.) are then added. For slow deposition: 16.5 cub. cm. of 0.057 molar silver solution, 1.0 cub. cm. of, molar cane sugar, 0.5 cub. cm. of methyl alcohol (80 per cent.), 2 cub. cm. of formaldehyde (0.8 per cent.). This latter solution will deposit 20 per cent. of its silver in 40 minutes.

CARGO SHIP LINES OF SIMPLE FORM.*

By Naval Constructor William McEntee, U.S.N., Member.

The recent wide discussion and general interest in the possibilities of standard cargo ships to be built in large numbers from standard plans has naturally brought into prominence the matter of simplifying the form of ships. The tendency in ship construction for a long period has been in the direction of simplification. If, for example, the sailing vessels which formed the Spanish Armada, with their high poops and forecastles and overhanging galleries, are compared with the present-day ship, the effect of this tendency is shown very clearly. A part of the change has, no doubt, been due to the introduction of steam power and the increase in size of ships made possible by their construction of iron and steel, but even before the era of steam propelled iron and steel ships, the tendency toward simplification was having a decided effect. In this gradual change there has been a greater variation in the form of that part of the shed above the water-line. This is possibly due to the fact that there was more latitude in the upper works for the expression of individual ideas, or for artistic embellishment, than there was with the under-water body.

In order to make any reasonable progress through water the under-water form had to be of some reasonably good shape, and the practical limits of form variation were more restricted. An examination of the lines of one of the large boats, or small ships, used by the Norsemen nearly 1,000 years ago, shows that for their purpose the shape of the under-water body was almost equal to the best we have to-day. In general, the simplification of form requires the use of plain surfaces at right angles instead of curved surfaces wherever possible. Where curvature is unavoidable, the simplest of curves, the circle, should be used. All curvature should be in one direction only, that is, surfaces of double curvature should be avoided so far as possible.

These considerations lead, in the forming of a ship, to the adoption of a midship section formed by two vertical lines and a horizontal line at the bottom, the corners or bilges being rounded off by circles of suitable radius. The sides and bottom of the ship will be flat surfaces carrying the full midship section well forward and aft, making what is known as the parallel middle body extend as far as possible without excessive increase in resistance. Forward, where it is necessary to fine the lines to form an entrance, it can be done by gradually decreasing the width of the ship, keeping the bottom flat and the sides vertical, the bilge being formed by a quarter circle of constant radius equal to that used for the middle part of the vessel.

Aft, the possibilities of simplification are limited by the necessity for providing space for the propellers. Two different methods of simplifying the after body are shown in model 1,997 and model 2,056, Figs. 1 and 2, annexed. The general result in these forms is to make the water-line somewhat wider and place the displacement higher up. This arrangement seems favourable from both the resistance and the propulsion standpoints, but may have disadvantages as regard sea-going qualities.

In the present investigation an attempt has been made to show how the power required for propulsion is affected by simplification of the lines of three different types of cargo vessels.

Models 1,978 and 1,997, lines of which are shown on Fig. 1, are models of 160-ft. oil-fuel barge of 830 tons and 850 tons respectively. Through a slight error in making model 1,997, the cylindrical or prismatic co-efficient and displacement are somewhat larger than for the model with which it is compared, that is, No. 1,978, of conventional form. The effective horse-power curves for the estimated power are shown in Fig. 4. It will be seen that the curves are very nearly the same, the simplified form requiring about 35 effective horse-power at 6 knots as compared with 34 effective horse-power for the conventional form.

Models 2,023 and 2,056, line of which are shown in Fig. 2, are of a 400-ft. 10.5-knot cargo ship of the usual single-screw type. At 10.5 knots it will be seen from the power curves, shown in Fig. 5, that the simplified form requires something less than 2 per cent. greater effective horse-power than for the conventional form. As model 2,023 gave results which were considered to be good for this type of vessel, it follows that the simplified form, model 2,056, would require appreciably less power than many cargo ships of conventional form in this general class now built and building.

In Fig. 3 are shown the lines of the United States collier Neptune, and of a 500-ft. cargo vessel of simplified lines and somewhat greater displacement. The effective horse-power curves for these two models are given in Fig. 6. There is also shown the estimated effective horse-power curve for a 500-ft. ship of conventional form having the same displacement, 20,000

Fig. 1. LINES OF MODELS Nos 1978 AND 1997 REPRESENTING 160 FT. x 25 FT. x 9·25 FT. x 830 TONS FUEL OIL BARGES OF CONVENTIONAL FORM AND OF SIMPLIFIED LINES.

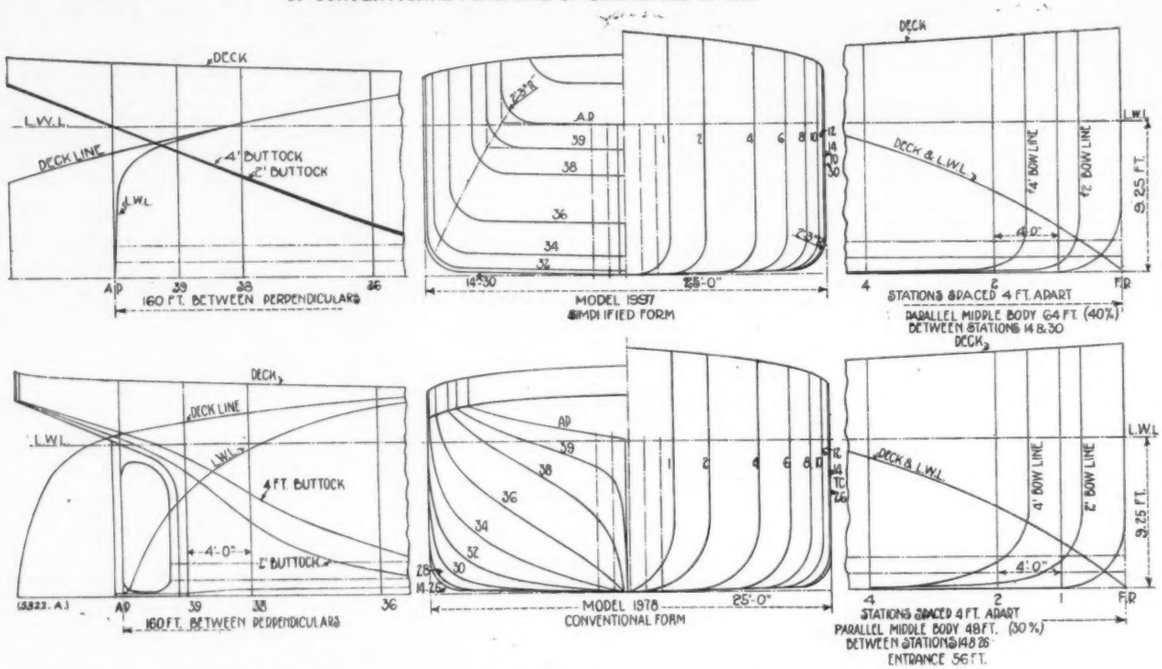
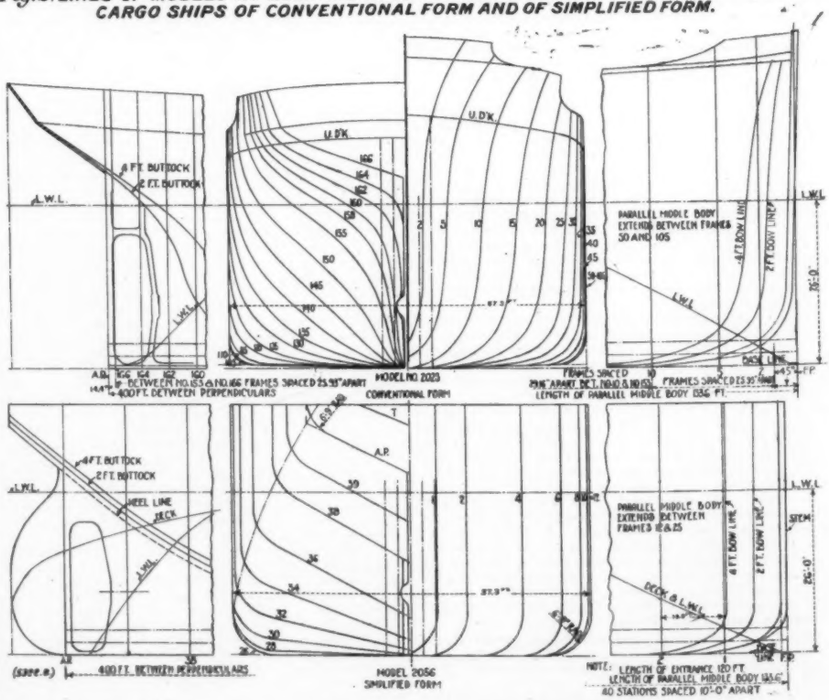


Fig. 2. LINES OF MODELS Nos 2023 AND 2056 REPRESENTING 400 FT. x 57·3 FT. x 26 FT. x 13,137 TONS CARGO SHIPS OF CONVENTIONAL FORM AND OF SIMPLIFIED FORM.



* Paper read before the Society of Naval Architects and Marine Engineers, in New York, November 15.

tons, and the same cylindrical or prismatic coefficient, 0.74. This latter curve is estimated from tests of one of a series of models of conventional form. The simplified form requires a little more power than the latter for speeds up to 13 knots. From that up to a speed of about 17 knots, the simplified form is the better, the advantage at a speed of 15 knots being in the neighbourhood of 7 per cent. On the same diagram it will be seen that the Neptune, which is of the conventional form,

Fig. 3. LINES OF MODELS Nos 2045 AND 1121 REPRESENTING 500 FT. x 72·5 FT. x 26·375 FT. x 20,000 TONS CARGO SHIP OF SIMPLIFIED LINES AND 520 FT. x 65 FT. x 27·5 FT. x 19,340 TONS COLLIER.

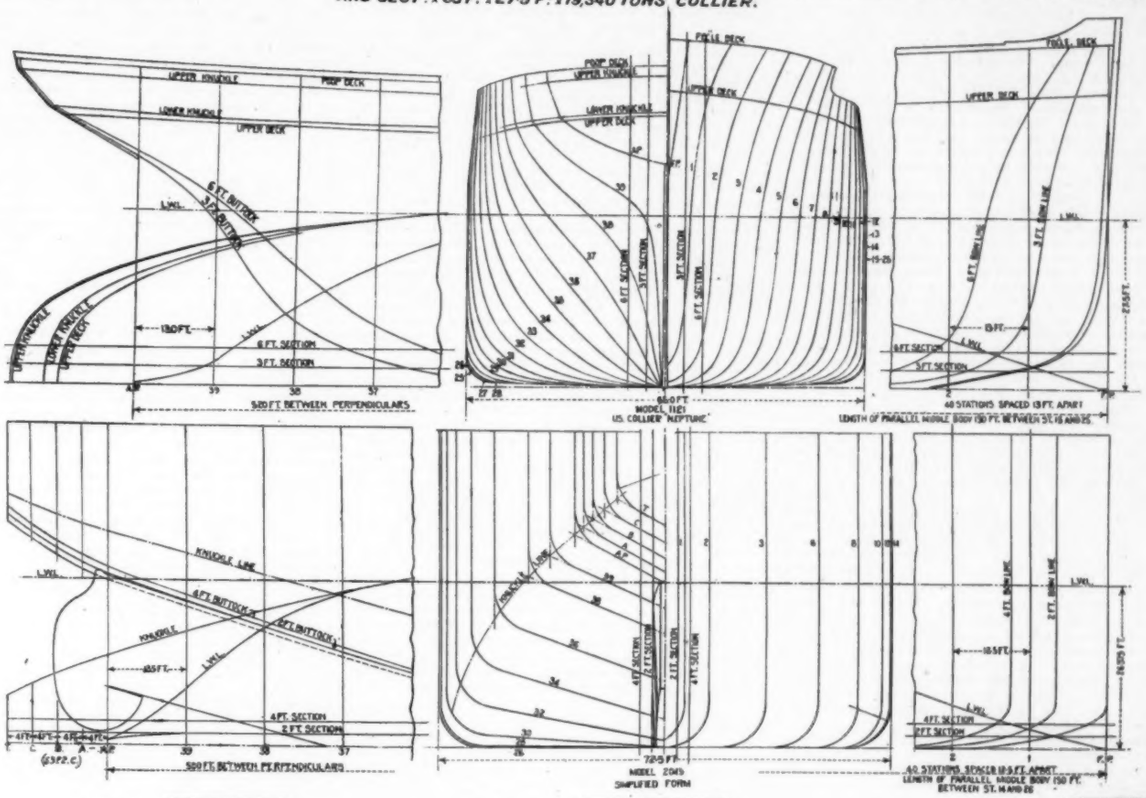
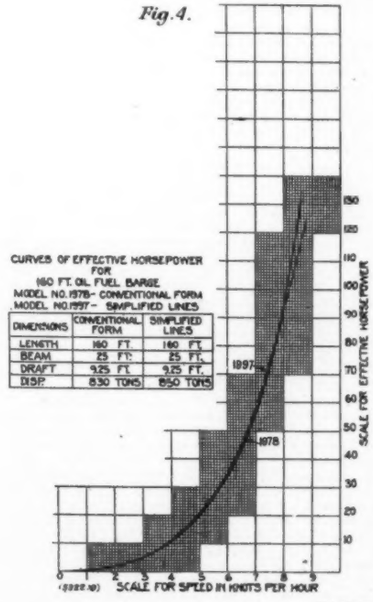
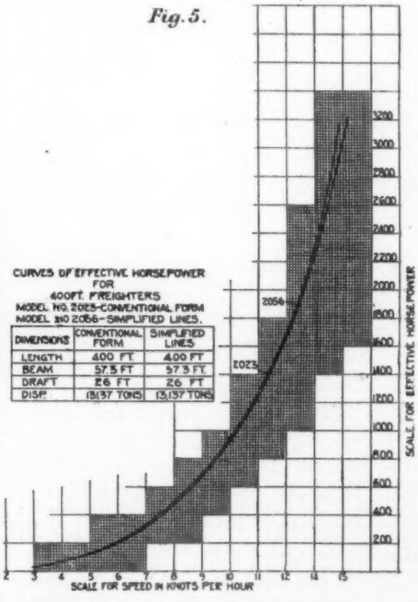

520 FT. BETWEEN PERPENDICULARS
MODEL 1121 U.S. COLLIER 'NEPTUNE'
40 STATIONS SPACED 13 FT. APART
520 FT. BETWEEN PERPENDICULARS
MODEL 2045 SIMPLIFIED FORM
40 STATIONS SPACED 18·5 FT. APART

Fig. 4.


CURVES OF EFFECTIVE HORSEPOWER FOR 160 FT. OIL FUEL BARGE. MODEL NO. 1978 - CONVENTIONAL FORM. MODEL NO. 1997 - SIMPLIFIED LINES
SCALE FOR SPEED IN KNOTS PER HOUR
SCALE FOR EFFECTIVE HORSEPOWER

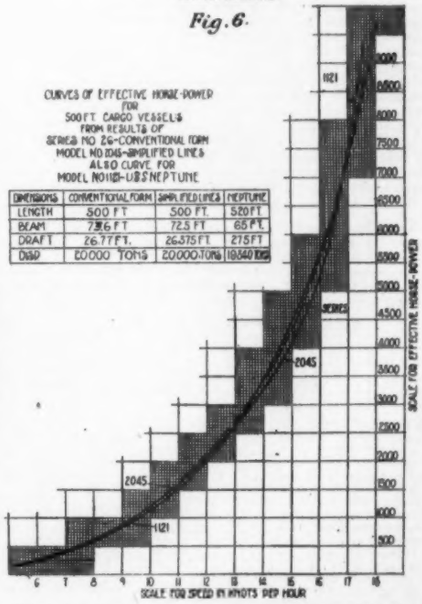
DIMENSIONS	CONVENTIONAL FORM	SIMPLIFIED LINES
LENGTH	160 FT.	160 FT.
BEAM	25 FT.	25 FT.
DRAFT	9·25 FT.	9·25 FT.
DISP.	830 TONS	850 TONS

Fig. 5.


CURVES OF EFFECTIVE HORSEPOWER FOR 400 FT. FREIGHTERS. MODEL NO. 2023 - CONVENTIONAL FORM. MODEL NO. 2056 - SIMPLIFIED LINES.
SCALE FOR SPEED IN KNOTS PER HOUR
SCALE FOR EFFECTIVE HORSEPOWER

DIMENSIONS	CONVENTIONAL FORM	SIMPLIFIED LINES
LENGTH	400 FT.	400 FT.
BEAM	57·5 FT.	57·3 FT.
DRAFT	26 FT.	26 FT.
DISP.	13,137 TONS	13,137 TONS

Fig. 6.


CURVES OF EFFECTIVE HORSE-POWER FOR 500 FT. CARGO VESSELS FROM RESULTS OF SERIES NO 26 - CONVENTIONAL FORM MODEL NO 1045 - SIMPLIFIED LINES ALSO CURVE FOR MODEL NO 1121 - U.S. NEPTUNE
SCALE FOR SPEED IN KNOTS PER HOUR
SCALE FOR EFFECTIVE HORSE-POWER

DIMENSIONS	CONVENTIONAL FORM	SIMPLIFIED LINES	NEPTUNE
LENGTH	500 FT.	500 FT.	520 FT.
BEAM	73·6 FT.	72·5 FT.	65 FT.
DRAFT	26·77 FT.	26·375 FT.	27·5 FT.
DISP.	20000 TONS	20000 TONS	19340 TONS

TABLE I.—DIMENSIONS.

Model No.	Type.	Length, Feet.	Beam, Feet.	Draught, Feet.	Displacement, Tons.	Speed, Knots.	E.H.P.	Long. Coefficient.	Midship Section Coefficient.	Parallel Middle Body, Per Cent.
1978	Oil fuel barge, conventional form	160	25.0	9.25	830	6.0	34.4	0.80	0.98	30.0
1997	Oil fuel barge, simplified lines	160	25.0	9.25	850	6.0	35.6	0.82	0.98	40.0
2023	400-ft. freighter, conventional form	400	57.3	26.0	13,137	10.5	1,080	0.788	0.987	33.4
2056	400-ft. freighter, simplified lines	400	57.3	26.0	13,137	10.5	1,120	0.788	0.987	33.4
*Series	500-ft. cargo vessel, conventional form	500	73.6	26.77	20,000	14.0	3,440	0.74	0.96	30.0
2045	500-ft. cargo vessel, simplified lines	500	72.5	26.375	20,000	14.0	3,290	0.74	0.989	30.0
1121	U.S. collier Neptune	520	65.0	27.5	19,340	14.0	3,460	0.738	0.983	25.0

* Estimated from Experimental Model Basin's Parallel Middle Body Series (No. 26).

but 520 ft. in length and of somewhat less displacement, that is, 19,340 tons, requires in general more power than is found by experiment to be necessary in a ship of corresponding size constructed on the simplified lines.

The main dimensions of the models, or rather of the ships represented by them, are given in table I, which is printed in the adjoining columns.

In general, it appears to be safe to conclude that cargo vessels can be built of simplified lines which will give practically as good results from the resistance standpoint as those built from the present conventional lines. If propulsive efficiency is also taken into account, it is believed that the simplified form will have, at least in certain cases, advantages over the more complicated forms of the present type.

COPPER IN QUEENSLAND.

The "Mining Annual," issued by the Queensland Government, is just to hand, and in its pages is the following information about copper deposits and mining in the State :—

"During the past year the pursuit of few, if any, minerals has been so enticing as that of copper, which now forms such an important factor in the State's mineral production. The substantial rise in the price of the metal which took place in 1915 was but a minor flight compared with the soaring altitude attained during the past year. Commencing at about 85*l.* per ton in January, by December the unprecedented figure of 150*l.* a ton was reached. The total copper output of the State for 1916 was 19,520 tons, of the value of 2,265,422*l.*, or 184 tons, less in quantity, but 836,629*l.* more in value, than for 1915.

"The vast Cloncurry field is assuming increasing importance as the chief copper-producing centre of the State. During the past year this district was responsible for a yield of this metal to the value of 1,149,328*l.*, which is greater than the value of the output of 1915 by over 432,500*l.*, and represents more than half the value of the total copper production, and considerably more than the aggregate gold output, of the whole State.

"The scheme for the establishment of central treatment works, outlined in last year's report, which was to have been inaugurated by the Mount Elliott Company, and which was to deal principally with the low-grade ores of the district, and with the Mount Elliott mine in particular, has so far not materialised, at least not on the scale predicted. Instead, the original Mount Elliott smelter has been increased in capacity, and, to work in conjunction with it, a concentrating plant, purchased from the Great Fitzroy mine, has been erected; and to these works ores from the various mines in the district will be drawn and treated until the company can get a better plant to carry out the work in the way they orginally intended. The smelting plant will, provided coke be available, be put in commission early in the current year—probably by the latter end of March. It is estimated to be capable of treating upwards of 500 tons of ore daily, or, say, 14,000 tons a month—a tonnage practically twice that which is being treated by the Hampden Company. The ore and fluxing material to feed the furnace will be drawn from the company's mines, and will in some instances have to be transported by rail over long distances. Customs ore will also be catered for, and if reasonable smelting charges are levied and the company accept low-grade ore, the small outside mine-owner should benefit considerably, both from an increased output and a higher price for his ore than now prevails.

"Although the object of a larger plant is to lessen the cost of treatment, and incidentally bring a lower-grade ore than is at present being treated within the payable zone, the Mount Elliott Company, it is understood, will not, just at the start, attempt to smelt anything below 5 per cent., but will commence on ores that will leave a reasonably safe margin, not taking any undue risks, but working their way gradually until the stage is reached where, with constant running and a normal output, the cost of production can be correctly estimated. With a large number of mines supplying ores of various constituents, making it possible to get a suitable smelting mixture, ores containing 5 per cent. copper, at the present market price of the metal, should be highly profitable. Just how far below 5 per cent. ores in this country can be treated profitably can be determined only by experience."

New Machinery and Plant in South Africa.—According to the report for 1916 of the South African Mines Department, new machinery and plant introduced into mines in the Union during the year 1916 amounted in value to 851,837*l.* (including diggers and works 16,023*l.*), the chief items being as follows :—

Transvaal.

—	Gold Mines.	Coal Mines.	Base Mineral Mines.
	£	£	£
Boiler plant (other than that of locomotives, traction engines, or steam wagons)	24,249	4,717	1,865
Headgear	15,160	1,942	—
Steam engines for winding	16,636	729	428
Steam engines for compressors (including compressors)	13,630	1,850	373
Pumps	35,973	1,535	229
Steam locomotives	5,576	8,000	—
Reduction plant	158,751	—	1,947
Treatment plant	108,998	—	2,376
Workshop plant	18,341	355	960
Electric generators and engines, hoists, locomotives, and motors	85,783	4,535	1,129
Power lines, transformers, bells, telephones, &c.	88,409	1,684	380

The most important items were reduction and treatment plant, obtained in order to increase the output in some of the newer mines. As regards the other Provinces of the Union, washing plant to the value of 4,268*l.* was introduced into diamond and coal mines in the Orange Free State during the year, and boiler plant, steam engines for compressors, washing plant and electric generators, engines and motors to the value of 14,904*l.* were purchased for the coal mines in Natal Province. The above-mentioned report, containing detailed particulars and statistics regarding the various types of machinery and plant in use in mines in the Union in 1916 may be consulted by British firms interested at the Department of Commercial Intelligence, 73, Basinghall-street, E.C. 2.

FOREIGN ENGINEERING PROJECTS.

We give below a few data on several foreign engineering projects, taken from *The Board of Trade Journal*. Further information on these projects can be obtained from the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2.

Spain.—The *Gaceta de Madrid* notifies that tenders are invited by the Madrid municipal authorities for the installation of plant in the "sanitary section" of the new municipal slaughter-house. The contract comprises the installation of complete plant for the industrial utilisation of carcases, entrails, &c., which cannot be used for consumption; apparatus for the sterilisation of meat; apparatus for the industrial preparation of animal blood; disinfecting chambers for clothes; steam generator; and wagons for the transport of carcases. Tenderers must also submit plans of the building or buildings in which it is proposed to house the plant mentioned; the erection of the buildings, however, is not included in the present contract, as that work will be undertaken by the municipality. Foreign competition will be admitted, tenders being certified by the local Spanish Consuls. Tenders will be received at the "Negociado de Subastas, Secretaria del Ayuntamiento," Plaza de la Villa 5, Madrid, up to January 2, 1918. A provisional deposit of 10,000 pesetas is required to qualify any tender. The *Gaceta* also notifies that tenders will be opened at the "Dirección General de Obras Públicas, Ministerio de Fomento," Madrid, on December 22, for metal and other constructional material on the first section of the Trans-Pyrenean Railway, from Ripoll to Puigcerdá, Province of Gerona. The estimated value of the contract is put at 530,794 pesetas. Work must be commenced within a period of thirty days from the award of the contract and concluded within one year. The *Gaceta* further notifies that tenders will be received by the municipal authorities of Barcelona, up to December 19, for the construction of sewers and accessory works in certain streets of that city, the estimated value of the contract being 130,054 pesetas.

Timber Orders.—The Board of Trade has issued an Order, dated the 4th inst., providing that no person shall, until further notice, export or remove from Ireland to Great Britain round or sawn timber of any description grown in Ireland, without a permit issued by or on behalf of the Controller of Timber Supplies. It has also issued an Order, dated the 4th inst., regulating the prices of timber grown in the United Kingdom.

Substitutes for Coal in Gas-making.—Sawdust and wood are, according to the *Journal des Usines à Gaz*, to be used in Switzerland and France as substitutes for coal. In Geneva, 10 per cent. of sawdust is added to the coal in vertical Bulb retorts; as an alternative, logs of wood, 3 ft. in length, are placed in the retorts, which then contain only charges of 260 lb. instead of 1,240 lb. of coal. Wood and coal are worked alternately on two benches, and the gases not being kept separate, the resulting tars are not acid. At La Chaux de Fonds, in the Jura, 375 lb. of sawdust are mixed with 66 lb. of coal in horizontal retorts which took 990 lb. of coal. In Neuchâtel the coal is mixed with 28 per cent. of coal. In Arcachon, in the Gironde district, heath roots are carbonised in 2½ hours; the charcoal is said to be superior to pine charcoal, and the gas satisfactory. A cargo of condemned flour was carbonised at Royan, giving a very good coke free of ash. The acid products of wood distillation have given some trouble and corrosion, which the alternate working of charges of coal and of wood diminishes.

The Effect of Pickling upon Steel.—In an account given by *The Iron Age*, New York, of a recent meeting of American Electrochemists, reference is made to a paper by Mr. J. Coulson, in which it was stated that to determine the embrittling effect of absorbed hydrogen upon steel pickled in different ways, samples of spring steel wire were pickled chemically by simple dipping in acid, also by electrolytic pickling, using them as cathodes or as anodes. Oscillation tests on the original wires, the same sand-blasted, and the three sets treated as described, showed the chemically cleaned and the cathodically cleaned to be very brittle, while the anodically cleaned had the strength of the original samples. Similar tests were also made with drill-rod steel, hot-rolled Bessemer, and cold rolled steel, after which mechanical tests were made as to strength, elongation and reduction of area. The chemically and the cathodically cleaned specimens again showed great brittleness, which was most marked with the high-carbon steels and less marked with the soft steels. At the same meeting Mr. T. I. Fuller related that he tested the breaking strength of seven untreated springs, then tested similar ones electrically copper-plated, pickled in sulphuric acid and tinned by dipping in molten tin and then copper-plated. The pickling makes them brittle, also copper-plating, but tin dipping before copper-plating is found to prevent embrittlement entirely. The facts are all in accord with the assumption that the absorption by the steel of atomic or nascent hydrogen liberated at the cathode is the cause of the embrittlement of steel springs in the plating bath. This embrittlement may be prevented by first dipping the springs in a bath of molten tin. The tin forms a coating on the steel which is impermeable to atomic hydrogen. Resin may be used as a flux in the tin dipping. The springs may be sand-blasted, but must not be pickled in acid. Steel springs may be dipped in molten tin at a temperature of 260 deg. C. to 300 deg. C. without appreciably changing their mechanical properties.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

South Yorkshire Coal Trade.—The market has been on the busy side throughout the week, and the scarcity of spot lots is as pronounced as ever. Dealers report that it is a matter of the utmost difficulty to purchase anything on the open market, and they receive little satisfaction from agents who declare that there is no prospect of an improvement in the situation. The pressure is the keenest for best steam hards, the South Yorkshire sorts being in very big request. Collieries have sufficient in hand with the contract liabilities, and have to work at the top limit to keep abreast of these orders. Cobbles, nuts and slacks are all tightly held, whilst gas fuel is wanted in very heavy tonnage for inland works. The shipping position is not absorbing the very large quantities as in the earlier part of the year, though the shipments to France, Italy and those for the Admiralty are still considerable factors. The house coal section is again surfeited with orders, and the easy tone of the recent weeks has not been maintained. Quotations :—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; and smalls, 9*s.* to 10*s.*, per ton at the pit.

Iron and Steel.—The new order of the Ministry of Munitions as to the increase in the price of pig-iron does not fulfil the expectations of the makers, and the opinion is held here that this is only an instalment of the Government intentions. There has been no mention of the Derbyshire makers, who supply Sheffield firms with a very large tonnage, and the reference to Lincolnshire makes, on which we draw to a very large extent is not very material. Lincolnshire foundry and basic are advanced 5*s.*, which brings them up more to the level of the other makes, but generally speaking the advances all round for this and other districts do not approach anything like what was contemplated. Here, the firms fully believed that an advance of 10*s.* or more would be conceded. Probably the last has not been heard on the subject. Meanwhile it is worthy of note that the output of the forge and foundry sorts has decreased in much the same ratio as the production of basic has improved, thereby establishing a connection between the two. The conversion of furnaces from one to the other was bound to have some such effect, but though the market is stringent for the two first-named, there is nothing in the shape of a very serious scarcity. The supply of hematites is on a regular and systematic plan which ensures even distribution as far as possible. Scrap of good quality is in active demand. The steel production is still on a mammoth scale, and the supplies for munitions are stated to be ample. Basic billets are plentiful, but the acid sort are not quite so easily secured. Small tools of the high-speed variety enjoy a very big inquiry, and additional plant is being devoted to their manufacture. Marine and aeroplane work continue to make headway, and satisfaction is felt at the progress recorded. A scheme is now on foot whereby the supply of material to the cutlery trade will be centralised in responsible hands and distributed amongst the different manufacturers in equitable fashion. This will remove many anomalies, and lead to the preservation of numerous export connections.

The Association of Engineering and Shipbuilding Draughtsmen.—On Saturday last (8th inst.) the London branch of this association held their first Bohemian Concert at the Holborn Restaurant, when an excellent musical programme was carried out. During the evening, the president, Mr. Ernest H. Walker, explained to a very crowded and enthusiastic meeting, that the objects of the society are the advancement of draughtsmen both technically and socially by organisation of the men, by the formation of branches at several centres where there might be reading rooms, and where the interchange of ideas could take place and mutual help find a means of making itself felt. On page 634 is an article on the Status of Draughtsmen.

Hydrogen Sulphide from Gob Fires.—It is generally admitted at present that iron pyrites favourably influences the oxidation and spontaneous ignition of coal, though only to a small extent. The fact was denied by the late Professor Vivian Lewes (Second Report of the Royal Commission on Coal Supply, 1904), because he had found in a case of spontaneous combustion that the sulphur was evolved as hydrogen sulphide H_2S_2, and not as sulphur dioxide SO_2, as it should have been "if the pyrites had anything to do with the fire." In a paper presented to the Chemical Society this summer (Transactions, pages 853 and 863) Mr. T. J. Drakeley, of the Mining College, Wigan, demonstrates that the sulphur is certainly evolved as H_2S during the initial stages of a gob fire in a mine, but that this fact does not at all disprove the connection of sulphur dioxide with the fire. Heated coal and iron pyrites may give rise to the formation of H_2S by several reactions: simply by heating the coal, by passing SO_2 over hot coal, by heating mixtures of coal with sulphur or iron pyrites, by passing water vapour or dry or moist hydrogen, or moist carbon dioxide over heated pyrites. All these reactions are likely to occur in a gob fire, but the originally-formed SO_2 would hardly be liberated into the mine atmosphere previous to an external outbreak of the fire. If the SO_2 were not completely reduced to H_2S by contact with hot coal in the immediate vicinity of the fire, it would encounter large volumes of H_2S, issuing from the gradually heated material of the locality, and would be reduced to sulphur.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Market.—The announcement we made a week ago of advances in pig-iron prices has been officially confirmed. Provision making the advances retrospective is causing little trouble so far as home sales are concerned, as for some time past contracts have been made subject to any official alteration in quotations, and practically all the sales have already been put in order, but matters are not quite so easily adjusted so far as export transactions are concerned. The market continues steady and strong. Home demand for Cleveland foundry pig is now very small, consumers generally, having covered their needs under the December allocations, but forge-iron, which quality does not come under the system of allotment, is selling fairly well, rather substantial parcels having been disposed of for delivery next quarter. Export trade is only quiet, though there are good inquiries for delivery abroad to the end of March, and though many makers are reluctant to commit themselves to any great extent, a few good sales to the Continent have been made for dispatch next year. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge, all stand at 95*s.*, and No. 1 is 99*s.*; and for shipment to France and to Italy, No. 3 is 116*s.* 6*d.*, No. 4 foundry 115*s.* 6*d.*, No. 4 forge, 114*s.* 6*d.*, and No. 1 121*s.* 6*d.*

Hematite Iron.—Continued careful distribution assures regular deliveries to home customers on a scale sufficient to meet immediate needs, and hope is expressed that 'ere long the position will admit of some expansion of foreign trade. Nos. 1, 2 and 3 East Coast brands are 122*s.* 6*d.* for home use and 147*s.* 6*d.* for export to France and to Italy.

Coke.—Coke continues in good request for local use, and as supply is quite plentiful no difficulty is experienced in putting through business, with the result that the market is fairly active. Average blast-furnace kinds are 33*s.* at the ovens, and qualities low in phosphorus 35*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—It is almost impossible to negotiate ordinary commercial business in finished iron and steel, as output is practically absorbed by the huge Government requirements and the heavy needs of the shipyards. Manufacturers are still working at high pressure to cope with these demands. Up to the time of writing home maximum prices and export quotations are unchanged, but announcement of readjustment is expected at any time. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Ironworkers' Wages.—According to the accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, the average net selling price of iron bars and angles for the two months ended October 31 was 13*l.* 15*s.* 4.29*d.*, as compared with 13*l.* 13*s.* 4.43*d.* for the previous two months, and under sliding scale arrangements ironworkers' wages for December and January remain the same as prevailed during the preceding two months.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Towards the end of last week business assumed a very uncertain character, and collieries became very apprehensive as to the outlook, and it was feared that stoppages would be numerous, and up to Monday of this week stagnant conditions prevailed on the market. Steam collieries, for the moment, were the most affected, and in many instances collieries were unable to keep their pits going. Fortunately, however, later on in the week matters improved to an appreciable extent. The result was that collieries were kept working more regularly than has been the case since the middle of November. There is but little new business passing, but outputs are being absorbed by official requirements and contract commitments. Except for inland purposes there has been little doing in coke and patent fuel. Pitwood is scarce and firm up to 75*s.*

Newport.—Conditions improved this week on the Newport market. The new allocations for the supply of house coal to the South-Western counties are now in force, but the value of this business will depend upon the quickness with which wagons are taken to their destinations and returned to the collieries. There is unquestionably room for improvement in this connection, and if the Coal Controller is able to secure the maximum efficiency in connection with this particular branch of the inland trade something tangible will be done to diminish the amount of slack time in the Monmouthshire coalfield.

Coal for South-Western Counties.—The colliery companies have now received their new allocation certificates with regard to the supply of house coal to the South-Western counties. This is the third or fourth time that the quantities of coal allocated to the different collieries have been altered; there is some grumbling against the changes for they involve not merely increases or decreases in the quantities to be supplied, but also in the factors to whom deliveries are to be made. The new allocations took effect on Monday, and these relate, it is estimated, to between 60,000 tons and 70,000 tons per month, or approximately one-third of the house coal imported by the South-Western counties from South Wales, Forest of Dean and the Midland coalfields, and will be invoiced to merchants at the increased price of 25*s.* per ton at the pit head. The coals affected are almost exclusively Monmouthshire, and as against the disorganisation in trading and transport arrangements which the new allocations may produce must be set the advantage of an increased demand for coals.

Problem of Slack Time.—The Commission of Inquiry into the problem of slack time met the latter end of last week. Although no official report has been issued, it is stated that the report for which the Coal Controller is pressing will be delayed a little. Highly important issues have been raised, and it is doubtful whether the Commission can agree on recommendations without consultations with representative bodies of the employers and workmen.

Pooling of Italian Coals.—The pooling scheme for the supply of coals to Italy has been adopted, after certain amendments had been made in the original scheme. A representative meeting was held on the Cardiff Exchange on Friday last for the purpose of considering the changes in the draft scheme. It was agreed that, as amended, it should come into operation as from January 1 next, and that a pittage of 1½*d.* per ton should be allowed to the firms actually doing the export business. In the first instance the business will be entrusted to the six firms who were the largest exporters before the war, the representatives of which form the Management Committee. Two members of this committee are to retire every three months, and are to be replaced by two others representing the next largest exporting firms. The distribution of the moneys pooled will take place quarterly *pro rata* to the percentage of the business done and the former business of the respective firms. It was also decided to approach the Italian Coal Commission with the object of securing the exporters' commission and brokerage for the pool on business done in excess of the arranged Government orders between October 31, 1916, and December 31, 1917.

DISODIUM NITRITE—ERRATUM.—In our paragraph on "Disodium Nitrite," on page 612 of last week's issue it was stated that "ammonia boils at 33.7 deg. C." The minus sign was left out; the line should have read: Boils at −33.7 deg. C.

STEEL TYRES ON WORN STEEL WHEELS.—An illustrated article by Mr. W. G. Murrin, of the British Columbia Electric Railway, Vancouver, is published in *Electric Railway Journal*, New York, showing how worn steel wheels are made into centres and equipped with steel tyres, to save cost. For both city and interurban equipments, steel wheels are selected of suitable dimensions, so that at their final turning they can be made into centres. The English method of tyre fastening by rolling the inside edge of the tyre over that of the centre, has been adopted for the city wheels, and the Midvale bolted tyre, now rapidly becoming standard, has been selected for the interurban wheels. Experience, so far, has shown that the use of steel tyres effects a saving over that of either solid steel or chilled-iron wheels. The amount of steel scrapped from a worn-out tyre is considerably less than for a solid wheel, and a market for scrap tyres can be found where wheel centres cannot be disposed of. The life of a tyre is about the same as that of a new steel wheel and averages about four years, during which time four cast-iron wheels would have to be installed.

ROYAL INSTITUTION.—The following are the lecture arrangements at the Royal Institution before Easter:—Professor J. A. Fleming, a course of six experimentally illustrated lectures, adapted to a juvenile auditory, on Our Useful Servants: Magnetism and Electricity: Magnets and the Magnetic Compass, December 27; Electricity and Electric Currents, December 29; The Electric Current as a Heater and Chemist, January 1; Electricity as an Illuminator and Doctor, January 3; Electric Dynamos, Motors, Transformers and Railways, January 5; Electric Telegraphs and Telephones, January 8. Professor W. M. Flinders Petrie, three lectures on Palestine and Mesopotamia; Discovery, Past and Future. Professor Arthur Keith, Fullerian Professor of Physiology, three lectures on The Problems of British Anthropology. Dr. Leonard Hill, two lectures on (1) The Stifling of Children's Health; (2) The Climatic Adaptation of Black and White Men. Sir R. T. Glazebrook, two lectures on The National Physical Laboratory. Professor Spenser Wilkinson, two lectures on Generalship: (1) A Battle of Napoleon's (Austerlitz); (2) A Campaign of Napoleon's (1806). Sir Napier Shaw, two lectures on Illusions of the Atmosphere: (1) Revolving Fluid and the Weather Map; (2) The Travelling Vortex and the Cyclonic Depression. Edmund Gosse, three lectures on Three French Moralists and their Influence on the War: (1) La Rochefoucauld; (2) La Bruyere; (3) Vauvenargues. Sir Alexander C. Mackenzie three lectures on War Music: Past and Present. Professor William J. Pope, two lectures on The Chemical Action of Light. M. Paul H. Loyson, two lectures on The Ethics of the War. Professor Sir J. J. Thomson, six lectures on Problems in Atomic Structure. The Friday meetings will commence on January 18, when Professor Sir James Dewar will deliver a discourse on Studies on Liquid Films. Succeeding discourses will probably be given by Professor J. Townsend, Professor A. S. Eddington, Principal E. H. Griffiths, Professor Arthur G. Green, Professor E. H. Barton, Professor Sir J. J. Thomson and other gentlemen.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Sulphate of Ammonia.—The Board of Agriculture for Scotland, with a view to assisting agriculturists to obtain adequate supplies of sulphate of ammonia, is urging them to take delivery at the earliest possible moment in order to relieve the pressure at the producing works where, in most instances, there is not much accommodation for very heavy stocks. Very little is still available for order, and from now on it will be a case of "first come, first served." Considering, therefore, the national importance of sulphate as a fertiliser, delays are dangerous.

Scotch Steel Trade.—So far as the steel trade is concerned no change of any moment has taken place during the week, every establishment is full up with work, and every mill is running night and day unceasingly in order to make some attempt at maintaining the outputs at the required level. Government's wants are many and pressing, therefore makers have neither time nor opportunity for considering new business, despite the fact that much of this is what must be depended upon in the future. Still nothing definite has been made known regarding the increased cost of production to makers, following upon the recent advance in the price of coal and coke, although the idea is gaining ground that some move may be made by Government to subsidise pig-iron. Steel for shell bars, and all kinds of finished and semi-finished material required for shipbuilding purposes continue in the greatest demand.

Malleable Iron Trade.—Not altogether to the liking of some malleable iron makers are a few of the changes which have taken place lately. For instance, the substitution of Government contracts, at fixed and keen prices, for the ordinary mercantile business of pre-war days when the Government control of costs, &c., was a matter unknown and undreamt of, rather upsets the equilibrium of people whose notions are conservative and unchangeable. The nation's necessity, however, is of paramount importance, and the malleable iron required for purposes of war must be forthcoming, and the pressure for delivery is strong. Government requirements have absorbed the export trade meantime.

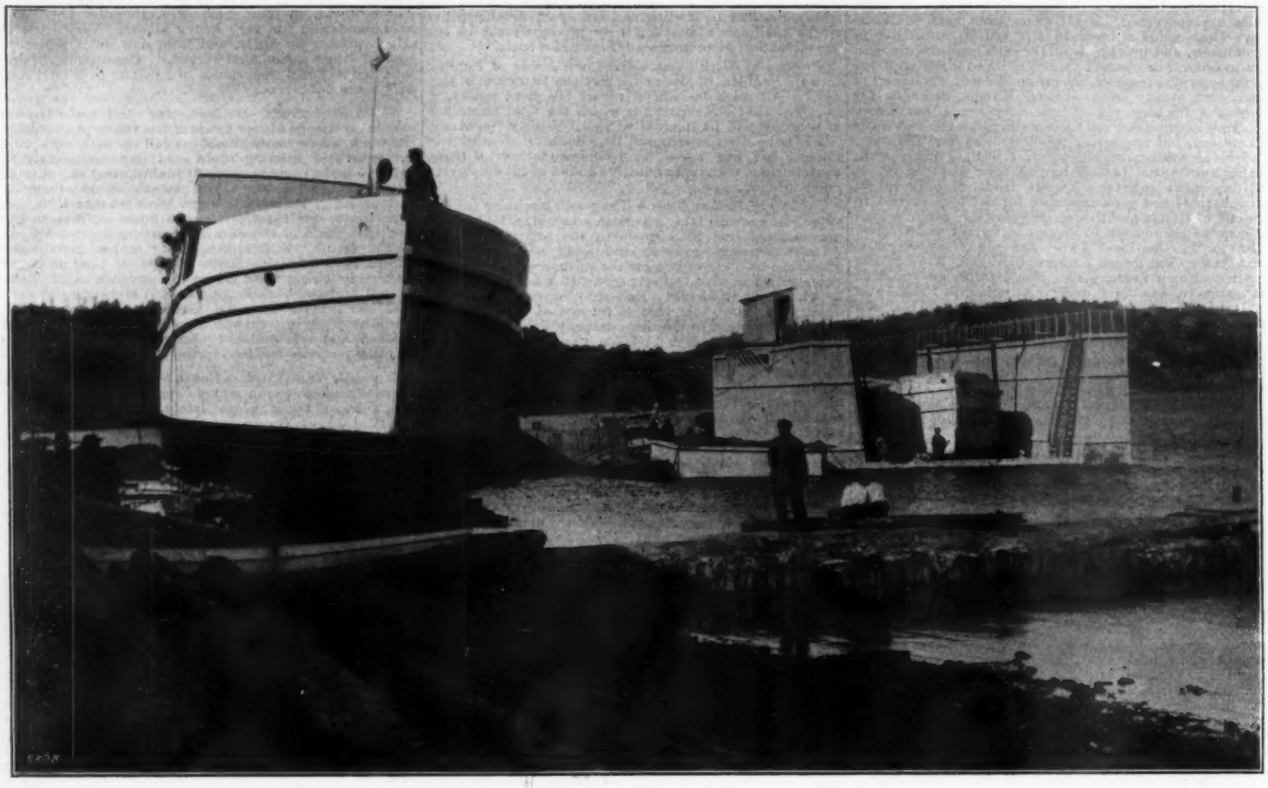
Scotch Pig-Iron Trade.—The keen and insistent demand for all pig-iron, and notably hematite, continues with unabated vigour, although the scarcity of certain brands is being distinctly felt. Fortunately the production goes on apace and under the new scheme of distribution it has been found possible to adjust supplies in a more equable direction and in a manner best calculated to meet the needs of the moment. To what extent the advance of 2*s.* 6*d.* per ton on the price of English pig-iron will affect the Scotch markets is not quite known yet, although it is absolutely certain that it will have a distinct effect. Export has dropped down to the lowest level.

Scottish Steelworkers' Wages.—A further advance of 5*s.* per week has just been granted to the members of the National Union of General Workers (Scottish District) through an agreement having been come to—subject, of course, to the approval of the Ministry of Munitions—between the union and the Scottish Steelmakers' Wages Association. Semi-skilled and unskilled workers, both on time and piece rates, are also to benefit by the increase which dates as from December 1. An award of 5*s.* per week for men over 18 years of age and 2*s.* 6*d.* per week for those under 18 has also been made by the Committee on Production to engineers, boilermakers, blacksmiths, hammermen, joiners and patternmakers employed in the West of Scotland steel works, dating from the first full pay in December.

THE SWISS ENTENTE COMMITTEE.—As announced on page 597 *ante*, Mr. Paul Fer, the London correspondent of this committee, delivered his lecture on "Switzerland in War Time and the Commercial Fight in Switzerland against German Penetration." A very large portion of the interesting statements which he made on this occasion are of a political nature, and are outside the scope of our columns. We may note that according to the speaker the United Kingdom, although the fifth country in the Swiss list in regard to trade importance, is the best customer of Switzerland, since the British purchases in Switzerland exceed by about 100,000,000 francs (4,000,000*l.*) the Swiss purchases in this country, the reason being no doubt that the British purchasers have learned to appreciate the excellent quality of the Swiss goods. These are mainly ribbons, silk fabrics, embroidery, machinery, chocolate and condensed milk. In 1913, Swiss exports to the United Kingdom amounted in value to 236,000,000 francs (9,440,000*l.*); in 1914, five months of which were covered by the war, the total was lower by 80,000*l.* only. Switzerland imports from the United Kingdom mostly cotton and cotton goods, iron, precious metals and a comparatively small quantity of coal. The possibility of an increase in the commercial intercourse between Switzerland and this country, said Mr. Fer, is an indisputable fact. As much as 80 per cent. of the coal needed in Switzerland comes from Germany, but the day is not far distant, the speaker hoped, when Switzerland would be in a position to utilise to the full the energy available in her numerous waterfalls. In regard more especially to the German penetration into Switzerland, he complained of the unbounded insistence of German commercial agents backed by their Government, of the poor quality generally of German goods, and of the attempts made by Germany to buy the Swiss press, attempts which have been successful in several instances, with results which can well be imagined.

FERRO-CONCRETE MOTOR-SHIP AND DOCK.

CONSTRUCTED BY THE FOUGNER FERRO-CONCRETE SHIPBUILDING COMPANY, CHRISTIANIA, NORWAY.



The Fougner Ferro-Concrete Shipbuilding Company, of Christiania, was founded by Mr. Nic. K. Fougner, the Norwegian engineer, who is the managing director. Long before the war, Mr. Fougner experimented and developed his ideas and patents in the United States, Great Britain, and for the last four or five years, in the Far East. Having thus satisfied himself through practical experiments that the scheme was feasible and practical, Mr. Fougner returned to his native country after twelve years absence, and began building ferro-concrete lighters. In May, 1910, a company was formed with a capital of about £27,000, and a yard built at Moss, near Christiania.

The motor-ship "Namsonfjord" was the first sea-going vessel built entirely of ferro-concrete upon Fougner's system. It is of 200 tons d.w., driven by a Bolinder crude oil-engine, 80 b.h.p., which gives the vessel a speed of 7½ miles per hour. Three months ago it was thoroughly tested in a heavy gale, out in the Christianiafjord, with the Norwegian Shipping Authorities on board, and the vessel has since gone trading on the coast, and in the Christianiafjord with different cargoes, such as sand, flour and lumber, thereby showing its qualities, when carrying the heaviest, as well as the lightest, cargo.

The Fougner Company have on hand a great number of contracts for sea-going ships of various sizes. They build standard types of 600 and 1,000 tons d.w. motor-driven vessels for oversea and coasting trade. In a couple of months the two first vessels of these types will be completed. The company have enlarged their capital to, at present, £133,000, and expanded their yard, so that a yearly tonnage of about 30,000 tons d.w., can be produced when the whole plant is completed. Floating docks of a size able to lift vessels of 15,000 tons d.w., can then be constructed.

The practical advantages of the new shipbuilding method are especially the lower cost and greater rapidity of construction, as well as the reduced upkeep expenses, as no painting is required for the hull, excepting some composition on the bottom to prevent growth.

Fougner's Company have now obtained Lloyd's class A1 for Scandinavian coasting service for their steel-concrete motorships. It is, of course, most important and gratifying to the inventor that Lloyd's Register of Shipping have recognised the importance and promising possibilities of his new construction by giving it a class.

We have already published one view of this new vessel in our issue of November 2nd, on page 467, but in consequence of the very great interest attaching to this class of vessel, we give a further illustration above. It will be noticed that the ship was launched sideways, and that the yard is equipped with a floating dock, also of ferro-concrete. The further progress of the novel method of construction will be followed with great interest.

The World's Greatest Tungsten Mine.—The most remarkable tungsten mine ever opened in Queensland, and, it is stated, the richest in the world, is Larkin and Wade's, at Wolfram Camp, which, with a block on it (Leisner's Block), and other tungsten mines, has been acquired by the British Thermos Reduction Company, who are going into development, treatment and production in a big way. The Larkin and Wade mine—it was named after its principal shareholders—has been profitable for the last sixteen or seventeen years, and is still going strong. Wolfram, molybdenite and bismuth, and other metals, are found in payable quantities on this remarkable property. Bamford was famous for a number of rich, shallow properties, and the Mount Carbine and Koorboora districts have yielded a great quantity of tungsten metals, and the Kitchener, a new mine, is promising. The Neville, at Koorboora, was a remarkable mine; the prospectors, or those who immediately succeeded them, were Mr. Neville and a Russian. In those distant days very little indeed was known about wolfram or its price, and the mine was not very promising. Occasionally the Muscovite, a giant, and a man of moods, would become disgusted with the outlook and retire to his hut obstinately declining to return to work. His partner, Neville, though delicate in health, and slight in physique, was the moving spirit in the partnership. He could not work without a mate, so he would go to the Russian's hut, dilate on the possibilities of the mine and the price of the mineral. He would read the latest news on the subject of tungsten metals, and quote the various prices payable for ores of different percentages of tungsten. His enthusiasm would infect the Russian, who would return to the shaft and achieve wonders, until the "stop work" fit attacked him, only to be again talked away by the untiring and ever-hopeful Neville. The latter's faith in the mine and in the value of wolfram was eventually justified, but he did not benefit. The boom was long in coming, Neville and his partner abandoned the mine, and the former did not long survive. The Irvinebank Tin Company took up the Neville, and opened up a remarkably rich body of wolfram. For many years the Irvinebank Tin Company has led the way in the munitions minerals business. In addition to being mineowners they erected treatment plants, and for some time have been treating the ores by the oil-flotation process. Their interests, it is now stated, have been acquired by the British Thermos Company. About seven years ago a French company, the Society of Rare Metals, erected a most expensive treatment plant at Wolfram, but the project died before treatment really commenced, and the plant has been largely dismantled and sold.

Wind Observations at the Nauen Radiotelegraphic Station.—In a communication presented to the Berlin Academy of Sciences (1917, pages 174 to 197), Professor S. Hellmann analyses the wind records from five instruments fixed on the masts of the Telefunken station of Nauen at heights of 2 m, 16 m., 32 m., 123 m. and 258 m. above the ground, for the years December, 1912, to August, 1916. Some data from Potsdam and other points are included in the analysis. The most interesting feature is the diurnal fluctuations of the wind velocity, which is best explained by reference to graphs. Close to the ground the nights are generally quiet, and the wind velocity rises in the morning and descends again in the afternoon. This shows plainly on the graph for an elevation of 2 m.; at 16 m. elevation the curve is flatter, and the maximum is retarded from 12 p.m. or 1 p.m. At 32 m. elevation the curve is still flatter, and there is a secondary maximum about midnight. At 70 m. above the ground the curve is almost horizontal, *i.e.*, the wind velocity changes little in the course of the day; this fact is rather deduced, than directly observed. At 123 m. the curve is reversed, that is, the maximum velocity occurs about midnight, the minimum about noon; this is still more so at an elevation of 258 m. The phenomena are considered to be in accordance with the theory of Espy-Köppen, but the night effect is stronger than was assumed. Thus the wind velocity decreases first as we rise from the ground, and the maxima are delayed, especially in summer; in the higher layers, above 70 m. or 100 m., the opposite holds. The velocity maxima observed were: 4.1 m. per second at 2 m. elevation (between 1 p.m. and 2 p.m.); 5.3 m. per second at 16 m. elevation (between 2 p.m. and 5 p.m.); 8 m. per second at 123 m. (between 10 p.m. and 11 p.m.); and 10.5 m. per second (about midnight) at an elevation of 256 m. About midnight in summer the velocities at the five heights, 2 m., 16 m., 32 m., 123 m. and 258 m., were, for example, 2 m., 3.5 m., 4.6 m., 7.5 m. and 7.6 m. per second.

THE SUNDERLAND SPUR AND SPIRAL GEAR PLANER.

CONSTRUCTED BY MESSRS. J. PARKINSON AND SON, ENGINEERS, SHIPLEY, YORKSHIRE

(*For Description, see Page* 617.)

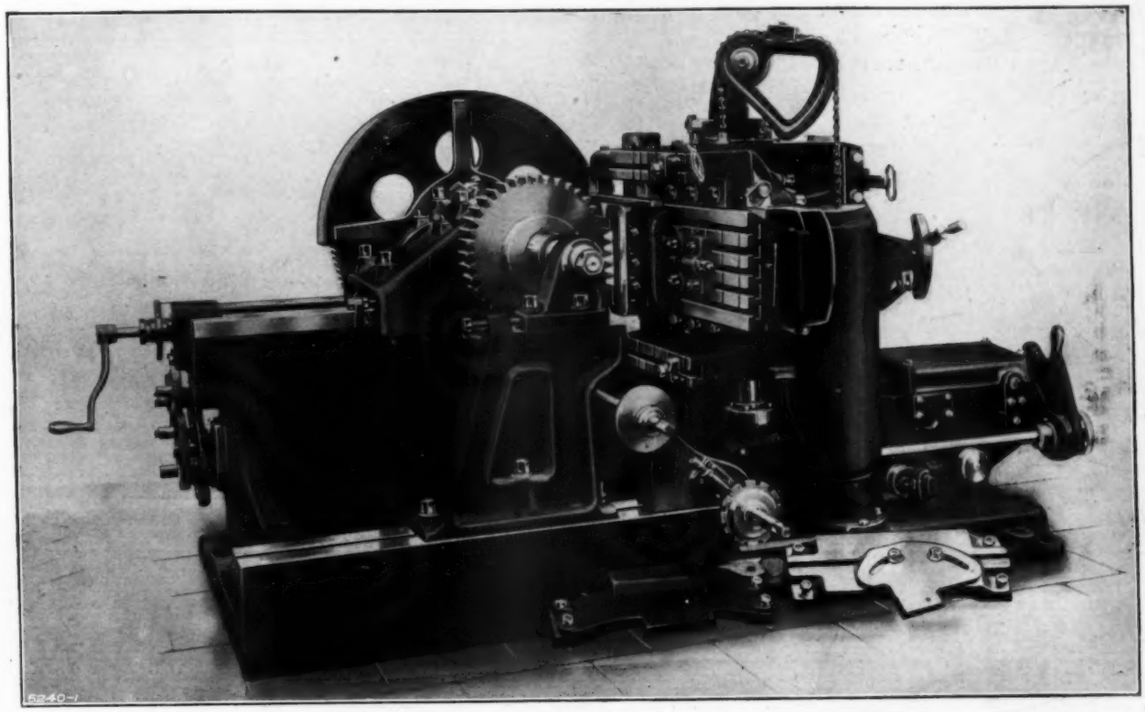


FIG. 1.

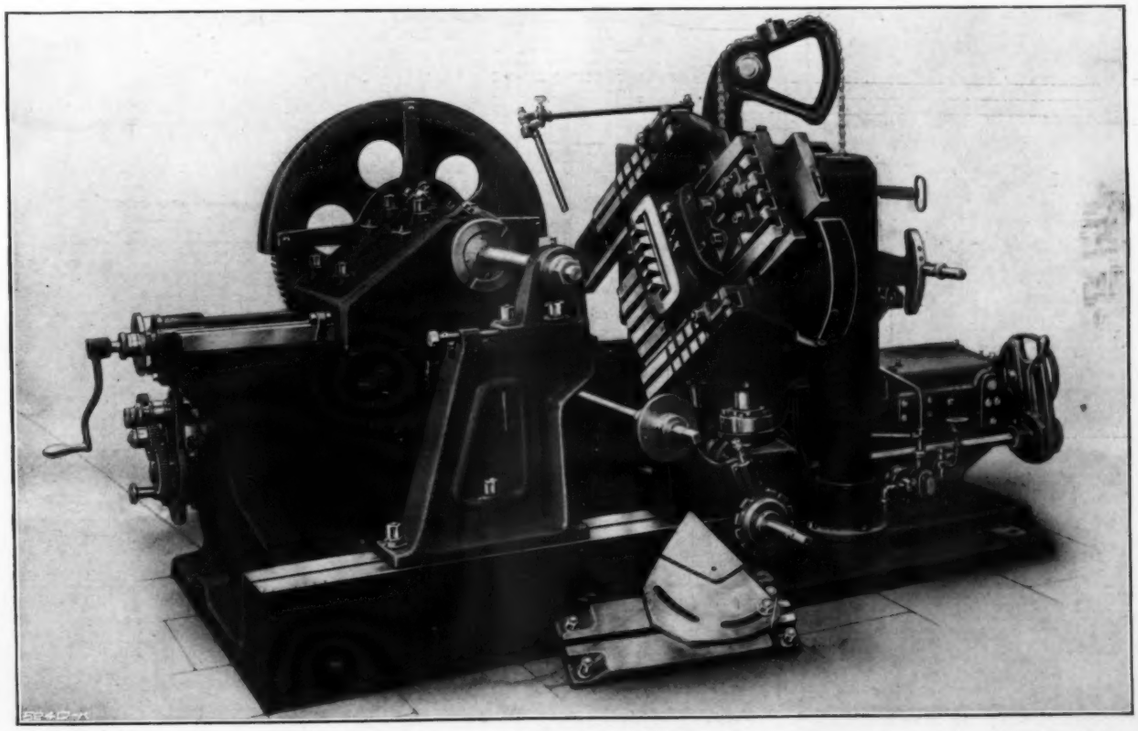


FIG. 2.

(*To face page* 618.)

THE SUNDERLAND SPUR AND SPIRAL GEAR PLANER.

CONSTRUCTED BY MESSRS. J. PARKINSON AND SON, ENGINEERS, SHIPLEY, YORKSHIRE.

(*For Description, see Page* 617.)

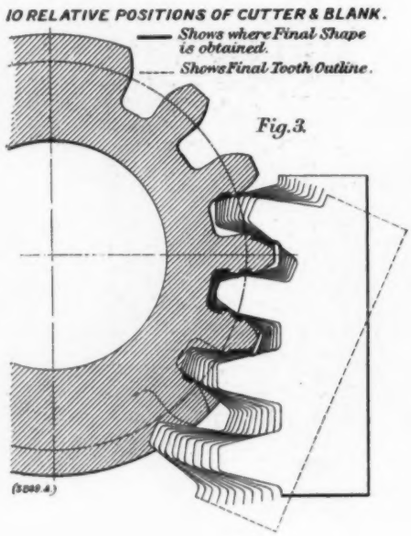


Fig.3.

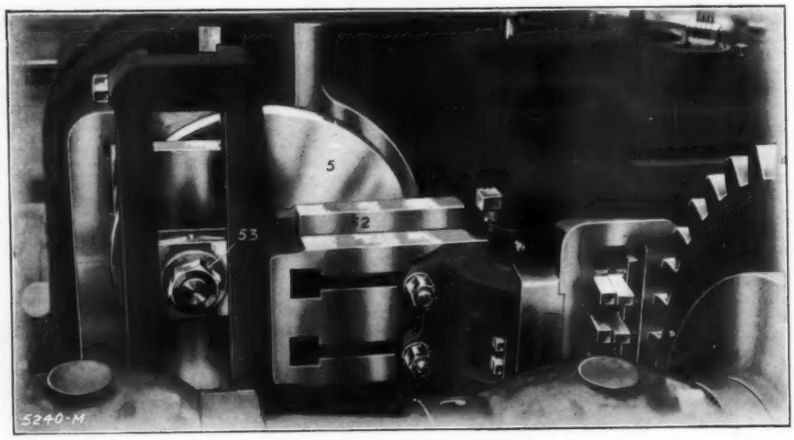


FIG. 5.

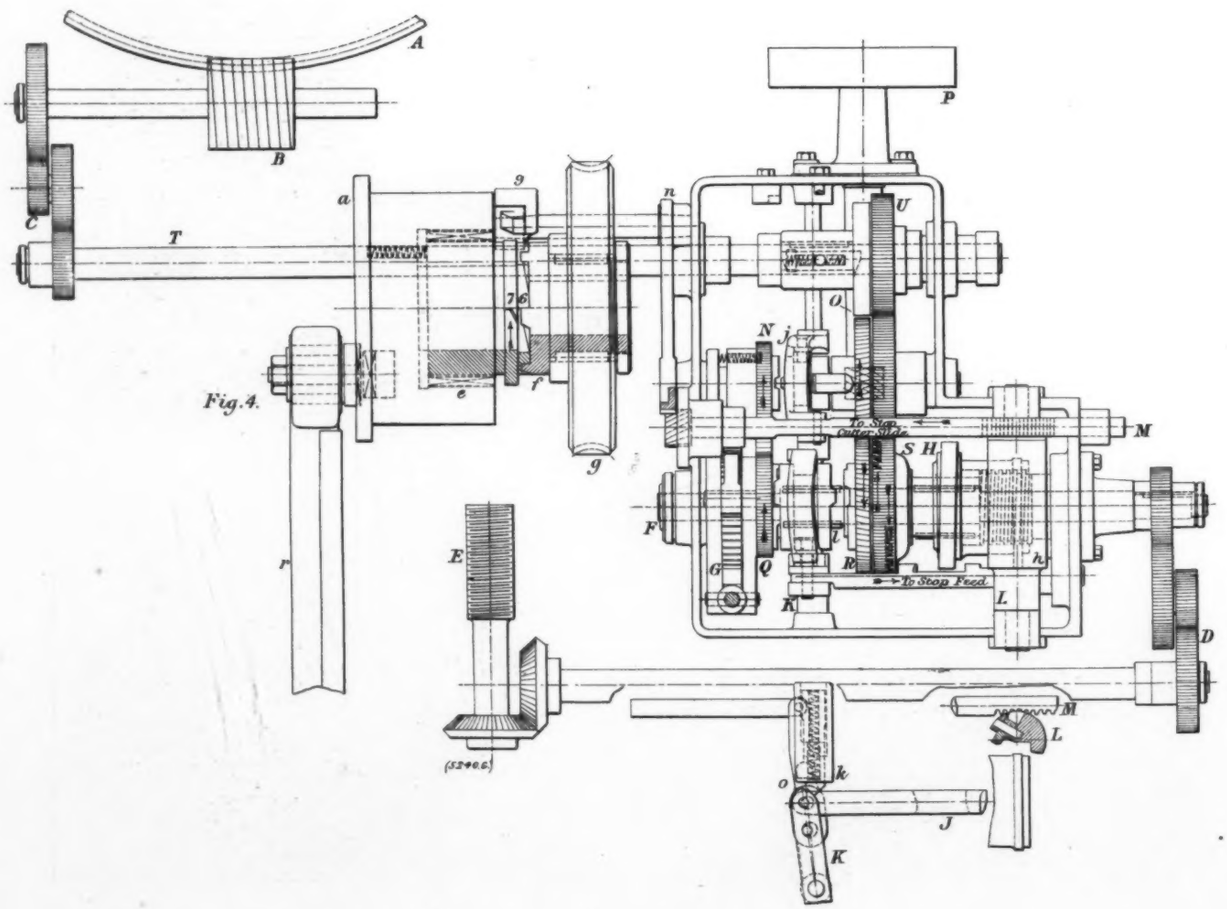


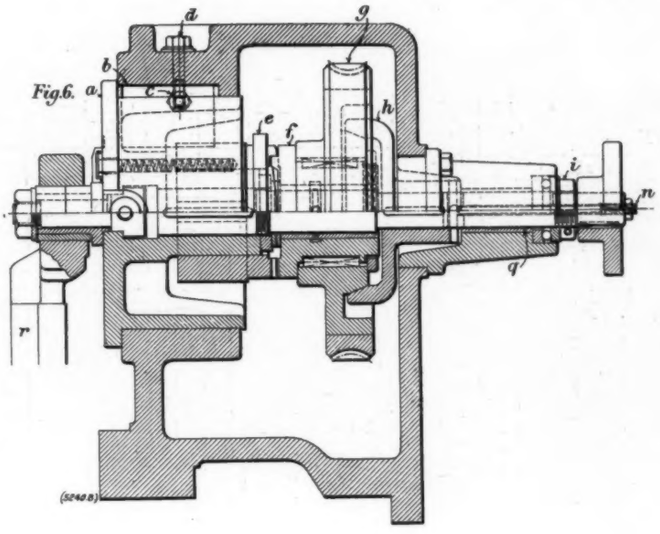
Fig.4.

THE SUNDERLAND SPUR AND SPIRAL GEAR PLANER.

CONSTRUCTED BY MESSRS. J. PARKINSON AND SON, ENGINEERS, SHIPLEY, YORKSHIRE.

(*For Description, see Page* 617.)

Fig. 6.



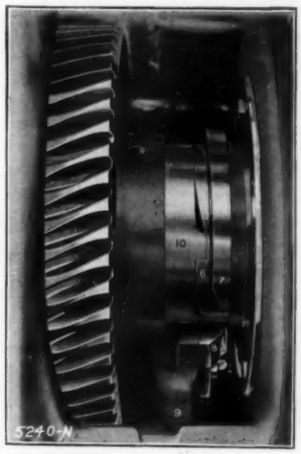
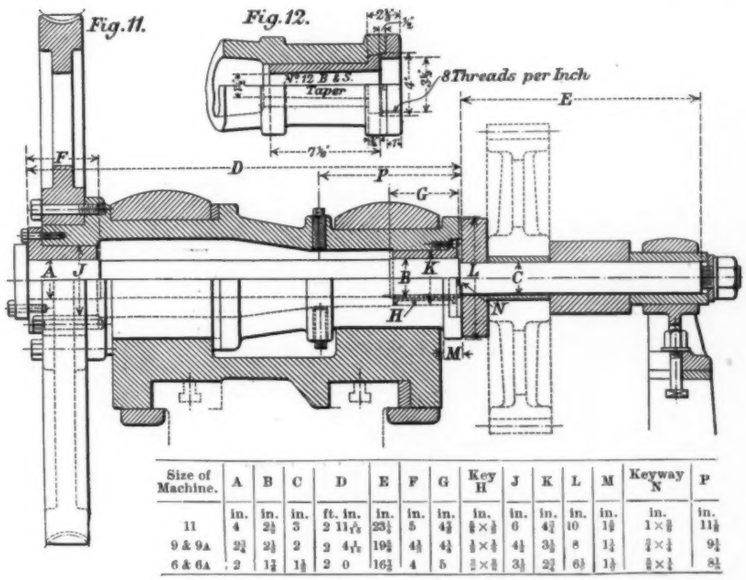


FIG. 7.

Fig. 11.

Fig. 12.



Size of Machine.	A	B	C	D	E	F	G	Key H	J	K	L	M	Keyway N	P
	in.	in.	in.	ft. in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
11	4	2½	3	2 11 1/16	23½	5	4⅞	⅝ × ⅜	6	4½	10	1⅝	1 × ⅝	11⅛
9 & 9A	2¾	2½	2	2 4 1/16	19⅛	4⅛	4½	½ × ⅜	4½	3½	8	1¼	¾ × ½	9½
6 & 6A	2	1½	1½	2 0	16½	4	5	½ × ⅜	3½	2½	6½	1⅛	⅝ × ½	8⅛

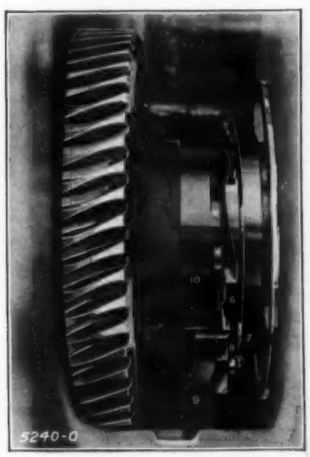


FIG. 8.

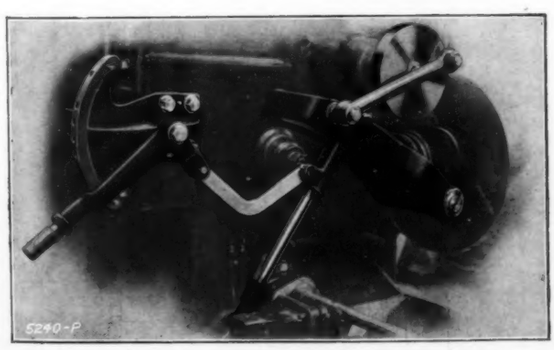


FIG. 9,

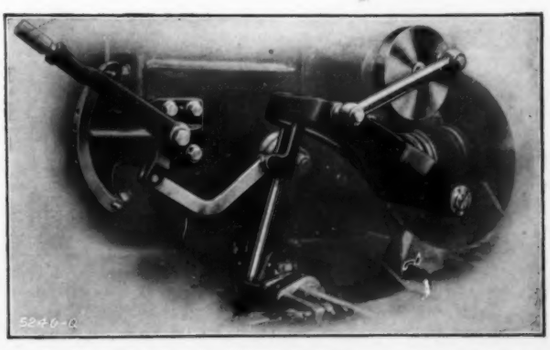
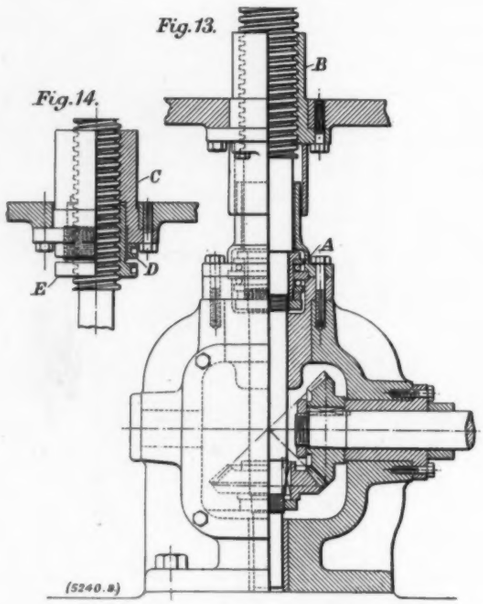


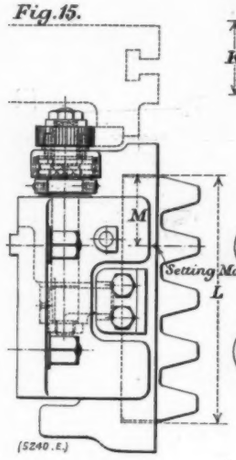
FIG. 10.

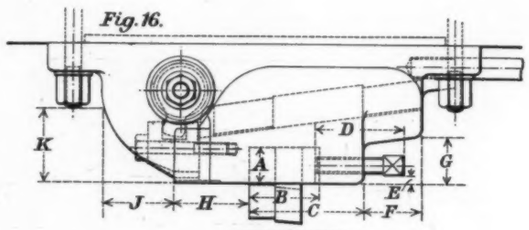
THE SUNDERLAND SPUR AND SPIRAL GEAR PLANER.

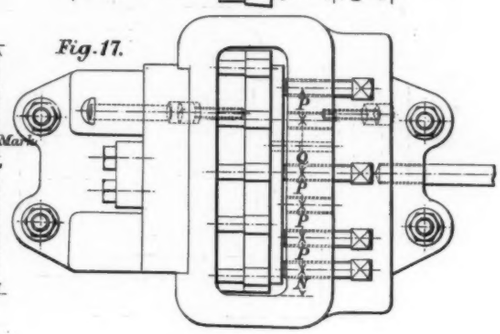
CONSTRUCTED BY MESSRS. J. PARKINSON AND SON, ENGINEERS, SHIPLEY, YORKSHIRE.

(*For Description, see Page* 617.)









DIMENSIONS FOR FIGS. 15, 16, AND 17.

Size of Machine.	A	B	C	D	E	F	G	H	J	K	L	M.	N	P	Q
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
11	$1\frac{3}{8}$	$2\frac{3}{8}$	$4\frac{3}{8}$	$3\frac{1}{4}$	$\frac{1}{8}$	$2\frac{5}{8}$	$2\frac{1}{4}$	3	$2\frac{1}{4}$	$3\frac{3}{8}$	$11\frac{1}{2}$	$4\frac{3}{8}$	$1\frac{1}{16}$	$4\times1\frac{3}{8}$	$1\frac{3}{8}$
9 & 9A	$1\frac{3}{8}$	$2\frac{3}{8}$	$4\frac{3}{8}$	$3\frac{3}{8}$	$\frac{5}{16}$	$2\frac{1}{4}$	9 $1\frac{3}{4}$ / 9A $2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{4}$	9 $3\frac{1}{16}$ / 9A $3\frac{7}{16}$	$9\frac{1}{2}$	$3\frac{1}{2}$	1	$4\times1\frac{1}{2}$	2
6 & 6A	$1\frac{3}{8}$	$2\frac{1}{16}$	$3\frac{5}{16}$	$2\frac{3}{8}$	$\frac{5}{16}$	$1\frac{3}{8}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$1\frac{1}{2}$	$2\frac{5}{8}$	6	$1\frac{3}{4}$	$1\frac{5}{16}$	$2\times1\frac{1}{2}$	1

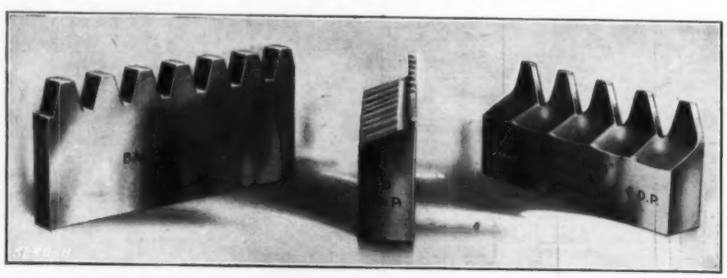


FIG. 18.

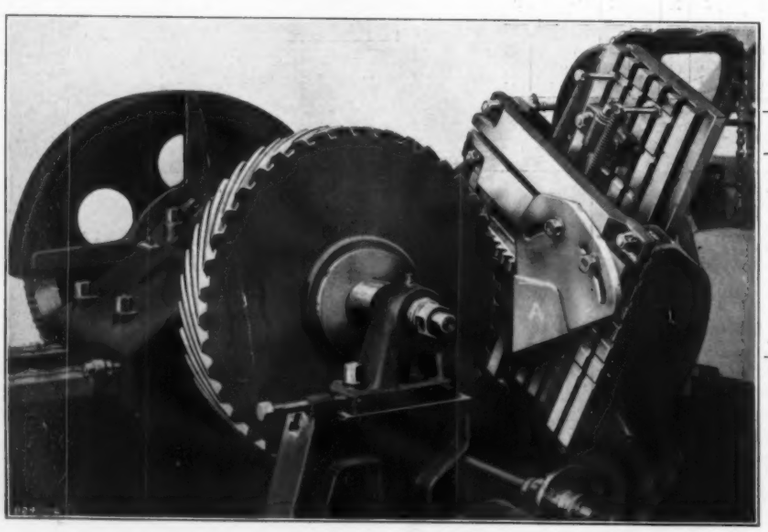
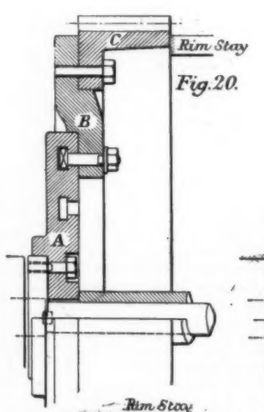
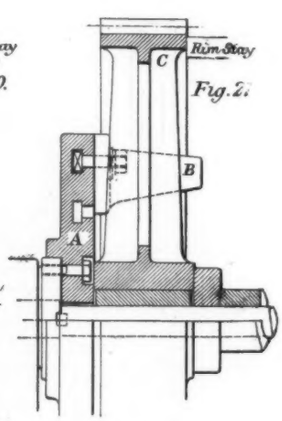
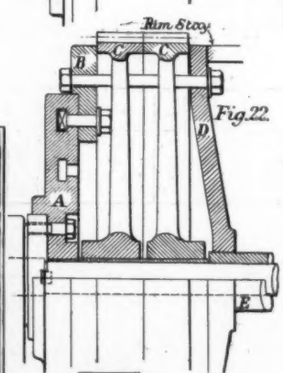
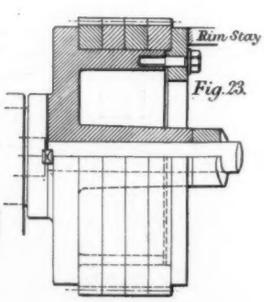


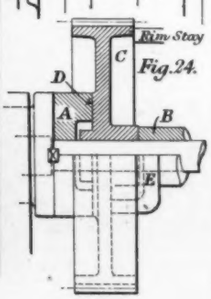
FIG. 19.

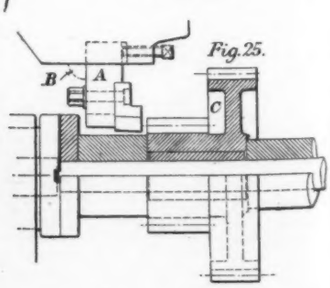












(*To face page* 619.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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TELEPHONE NUMBERS—3663 and 3568 GERRARD.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 14, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper: "The Use of Soap Films in Solving Torsion Problems," by Mr. A. A. Griffith, M.Eng., of S. Farnborough, and Mr. G. I. Taylor, M.A., of London.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 14, at 8 p.m., at 39, Victoria Street, S.W. "Rotary Engine and Rotary Pump," by Dr. W. E. Lilly.

THE ROYAL SOCIETY OF ARTS.—Monday, December 17, at 4.30 p.m. Cantor Lecture.—"Progress in the Metallurgy of Copper," by Mr. H. C. H. Carpenter, M.A., Ph.D., M.Inst.M.E., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology (Lecture III). Wednesday, December 19, at 4.30 p.m. Ordinary meeting.—"Science and the Cold Storage Industry," by Professor J. Wemyss Anderson, M.Inst.C.E., M.I.Mech.E., Dean of the Faculty of Engineering and Lecturer in Refrigeration, University of Liverpool. The Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand, will preside.

THE SOCIETY OF ENGINEERS.—Monday, December 17, at 5 p.m., in the apartments of the Geological Society, Burlington House, Piccadilly, W. A paper, entitled "High-Speed Railways," illustrated by lantern slides, will be read by Mr. B. W. Chalmers Kearney.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, December 18, at 8 p.m., at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2. The following paper will be read:—"The Prospective Oilfields of Barbados," by Mr. E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S. The chair will be taken by the President, Mr. Charles Greenway.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 18, at 5.30 p.m. Paper to be submitted for discussion:—"The Buenos Aires Western Railway Tunnels under the City of Buenos Aires," by Mr. William Lowe Lowe Brown, M.Sc., M.Inst.C.E.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 19, at 5 p.m., at 70, Victoria Street, Westminster. Papers to be read:—(1) "Computation of Wind Velocity from Pilot Balloon Observations," by Mr. P. Bolton, B.A. (2) "The Use of Monthly Mean Values in Climatological Analysis," by Mr. E. G. Bilham, B.Sc., F.R.Met.Soc.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, December 19, at 8 p.m., at the Royal Institution, Colquitt Street, when a paper will be read by Mr. A. T. Wall, Grad.H.N.C. (Greenwich), A.R.C.Sc., M.I.N.A., entitled "The Need for Research Work on the Propulsion of Ships."

THE CONCRETE INSTITUTE.—Thursday, December 20, at 5.30 p.m., at Denison House, 296, Vauxhall Bridge Road, Westminster, S.W. 1., when papers will be read by Mr. Ellis Marsland and Mr. H. Kempton Dyson, on "The Effects of Fire on Reinforced Concrete Buildings as Demonstrated by Some Recent Examples." There will be lantern illustrations and a general discussion. At the meeting opinions may be expressed freely by the authors of the papers and by subsequent speakers, but the authorities have forbidden the publication of any portion of the proceedings.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 20, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1. The following papers will be submitted for discussion:—"A Neglected Chemical Reaction and an Available Source of Potash," by Mr. E. A. Ashcroft, Member. "Syphoning Gravel," by Mr. J. Jervis Garrard, Member.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 21, at 7 p.m. Paper to be read and discussed: "Some Insufficiently Considered Details of Ship Construction and Equipment," by Mr. C. Waldie Cairns, M.Sc.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 14, 1917.

CHECKMATING GERMAN MONOPOLIES.

THE House of Commons is never at its best—we had almost written is ever at its worst—when discussing industrial economical questions. This is due first to lack of practical knowledge of manufacturing and commercial practice, and, second, to the obstacles which shibboleths and preconceived ideas set up against the acquisition of experience and the deduction of lessons from contemporaneous history. Until there is a large accession to the membership of men with intimate acquaintance with industry in all its ramifications, and without predilections on political topics, there will be little chance of British trade being unshackled from those bonds which have militated against freedom of expansion. The discussion last week, and this week, on the Bill for the control of Non-Ferrous Metals introduced by the Board of Trade, is full and conclusive proof of this. Prior to the war several manufactures were rendered impossible, and the development of others throttled by German control of the necessary raw materials. One example may be given. The making of high-speed steel, which is a vital necessity of all engineering, was checked by the difficulty of securing a free supply, on favourable terms, of the metals used, because these were monopolised by Germany, although, in large measure, a natural product of some of our Dominions. In the case of spelter our annual requirements were 200,000 tons, but we could only produce 60,000 tons. Germany, on the other hand, produced 283,000 tons, and Belgium, largely by Germanic-Belgian companies, 100,000 tons. Our output of munitions was thus seriously interfered with, and their supply to our troops greatly delayed. Indeed, it was in some instances only by decisive action by our Dominions that a change was effected.

What Parliamentarians do not always realise is that Germany adopts, in commerce, the flank instead of the frontal movement, and is as unscrupulous in trade operations as in war. The process of peaceful penetration has been so cunningly and insidiously pursued that it has not always been easy to recognise the political or international menace effected in otherwise apparently pure commercial enterprise. There have in our columns been many instances of subsidiary companies formed by German concerns, sometimes with nominal, oftener with actual control. It is not a question of recognising the naturalization certificate of this or other countries; it is rather one affecting the dominant control by Germans for Germany's direct or ulterior ends. It is not a case of shutting out legitimate free interchange of commodities, whether by allied firms or others. It is rather promoting the accepted necessity of freedom of expansion of British Imperial trade, of ensuring, as far as is possible, the greatest measure of independence for the supply of Imperial needs, particularly for a war of defence. At the Paris Conference it was resolved by all the Allies "to take the necessary steps, without delay, to render themselves independent of the enemy countries in so far as regards raw material and manufactured articles essential to the normal development of their economic activities." The Non-Ferrous Metal Industry Bill is a Parliamentary enactment partially to carry this resolution into effect.

All interested in industry welcome the proposals so far as revealed in the Bill. A German combine has, by methods already briefly indicated, contrived to control the supply of many metals, including spelter, lead, copper, aluminium and tin. They established financial interests in metal undertakings in all the leading countries, including the United Kingdom. Users could be denied the most favoured treatment. There was thus rendered uncertain, if not difficult, expansion in metal production and treatment. Some firms may not have had any cause of complaint—they may not suffer materially even after the war. But national interests and industrial supremacy must be the first consideration. The Bill aims at this end by carrying into effect the proposals of a committee of manufacturers appointed by the Board of Trade to the effect that all trace of German influence and association, direct or indirect, should be eliminated from any undertaking allowed to do business in this country. The Bill, therefore, provides that it shall be unlawful to deal in certain metals and ores to be specified in a schedule—without a licence, renewable annually, given by the Board of Trade after examination of books and documents to ensure that there was freedom from undesirable control. Penalties are to be imposed. The only objection worthy of consideration was as to Government control. We are not enamoured of such interference in industry. It is seldom free from disadvantage. It has a cramping influence generally. But in this case it is much the less of two evils and it is difficult to see how it can be obviated. The remedy, which we do not despair of realisation, is such a reform of the Board of Trade—long overdue—as will bring it more into harmony with industrial practice and aims. Nor do we place much importance on the objection to the inspection of books and documents of a company desiring a

licence. This is a safeguard against abuse, and there is no cause to believe that the information gleaned will not be regarded as in the highest degree confidential. As long as a firm is what it professes to be and is conducting its legitimate business in a fair way, with equitable treatment to all, it need not fear official examination. Other objections based on the still recurrent, but increasingly hollow spasms of Party politics, are here unworthy of consideration in any detail or seriousness.

THE STATUS AND REMUNERATION OF DRAUGHTSMEN.

In the general movement toward increased efficiency, which is now such a marked characteristic of the thoughts and endeavours of all concerned for the future success of industrial effort within the Empire, it is in the highest degree essential that due recognition be given to the fact that the measure of success ultimately attained must be largely influenced by the rapidity with which the advances due to scientific research are assimilated and the degree of success with which they are translated from the signs and symbols of the theorist to the designs and drawings supplied to the manufacturing shops. In this co-relation of theory with good and economical workshop practice the work of the draughtsman finds its highest expression, and it is doubtful whether the extent and value of the service thus rendered to industry have of late been realised either by employers or manual workers. Of the enormous importance of absolute accuracy in such calculations as lend themselves to direct mathematical treatment, and of sound technical prediction in the vastly larger number of cases where neither mathematical treatment nor data from actual experiment are directly applicable, there is evidence on every hand, while those directly concerned with the actual manufacturing operations will readily bear witness to the importance of a well-thought-out design in economising time and money in the shops. The very important alterations which have recently taken place in the design of war vessels and their machinery, aeroplanes, jigs and tools, &c., no less than the production at the shortest of notice of accurate detail drawings for the manufacture of the numerous new inventions relating to the mechanical side of war, have called attention to the importance of the work performed by the draughtsman, not only in relation to the demands of the present, but also in the development of all engineering schemes.

Keeping before us this high ideal of the professional work demanded of the draughtsman, and in view of the discontent which is becoming increasingly evident throughout the profession, it may be of interest to examine the present condition of affairs within the Drawing Office. As in the manufacturing shops, the trend of modern drawing office organisation—especially in the larger offices—has been all in the direction of specialisation, that is the confining of certain men to one class of work. Thus in many offices the practice has arisen of dividing the work up into departments, each under its own responsible head, and each dealing exclusively with one phase of the work. The modern engine works drawing office is split up into departments dealing with the work under the following heads: cost-estimating; design; details of engines and general arrangement of machinery; details and general arrangement of boilers. For the work of the first two of these departments a very high degree of technical training and extensive practical experience are necessary, but the number of men required for these departments is comparatively small. From the information supplied by the design department the details of castings, forgings, &c., required for turbine or reciprocating engines are worked out, and the necessary information supplied to pattern and machine shops. Following upon the fixing of the details of the main items the general arrangement of propelling machinery, boilers, auxiliary machinery, steam pipes, &c., is worked out. For the working out of machinery details as well as in the fixing of general arrangements, practical knowledge is even more essential than a high degree of technical knowledge, and in general it will be found that but a very small number of the men engaged on the latter classes of work are competent to take up the work of designing. The same applies more or less to the work in the drawing office of a general engineering factory and still more to one where products are specialised or standardised.

In the drawing-office of a modern large shipyard the staff would be grouped under three departments, viz., design and calculations, steel work, and arrangement. The first-named department is responsible for all preliminary designs and estimates for new work, preparation of scantling section for submission to registration society, and all investigations as to strength, stability, cargo and coal capacity, &c. In addition to this all calculations for detail work such as rudder areas and diameter of stocks, strength of derricks, girders, &c., are usually performed by this department. The steel department is responsible for all constructional steel plans showing in detail all the information required by the workmen for the working and erection of the various parts of the structure, for the ordering of all the steel plates and rolled sections required and, generally, for the issuing to the yard of all information relating to the steel structure. The arrangements department is responsible for the general and detailed arrangements of all passenger and crew accommodation, pumping, heating, ventilation, plumber work, lifeboat accommodation and stowage, handling arrangements, &c. In this way the original and ideal conception of the function of the draughtsman has been lost, and the present indefinite status originated. It may be well to state here that in less extensive offices, where the total number of men employed is small, this subdivision of labour cannot be carried out, and as a result the work of the individual draughtsman must of necessity embrace a wider field covering all departments.

It will be at once apparent that under the system of sub-division or specialisation the necessity for the highest degree of training in all the departments disappears and is replaced by the necessity for special knowledge of one branch of the subject, and, however much the fact may be deplored from the professional standpoint, the fact must be faced that a very large number of present-day draughtsmen are simply one or at most two department men. The advertising columns of any newspaper will bear this out. It must further be noted that the economic reasoning which condemns the employment of a highly skilled mechanic on work which an unskilled man or a woman can do, applies equally to the drawing office and justifies the employment of men with just the degree of skill and knowledge required for the work on which they will be employed—that is, where the employer is prepared to engage and dismiss such draughtsmen in strict accordance with the needs of the moment.

That this condition is not to the advantage of employer or staff is obvious, and as it is a fact that when work in the steel and arrangements departments is slack the work of the designs and estimates department is usually at its highest pressure, it follows that the ideal condition for all concerned is found where men from the temporarily slack departments can be drafted to the busy department with the certainty that they are experts at the work. This type of man is by no means so common as he should be, and to this fact must be attributed at least a part of the blame for the present indefinite status of the profession. A further defect of a peculiarly annoying character is the lack of practical knowledge or thought which is shown in the preparation of many working drawings issued to the yard. It is no uncommon thing, for instance, to find that in arranging the shell plating on a model no consideration is given to the simplification of furnaced plate work in way of bosses, &c.; keelsons, &c., crossing shell landings; disposition of caulking edges; access for riveting, caulking and painting; and many other points which involve extra labour and cost in carrying out the work in the yard. In the same way engine parts are far too frequently designed with but little regard to machining and finishing operations in the shops. This fault is entirely due to faulty training during apprenticeship—to the lack of practical experience of work and working conditions which is such an indispensable part of the training of all draughtsmen. It is indeed no exaggeration to say that a good drawing office staff in a large works will by careful attention to practical points—small in themselves it may be—save many hundreds of pounds of needless expenditure in the yard and shops.

The raising of the status of draughtsmen is therefore a matter which lies to a very large extent in their own hands, and the preliminary step would naturally take the form of an assurance to employers and others that each member of the profession had attained to a satisfactory degree of proficiency in all branches of his profession. Such an assurance would be of benefit to employers and employed alike, and is certainly the most convincing argument in favour of improved status. To the employer there is the assurance that each member of his staff can deal adequately with all the problems which he may meet, and that a smaller staff of highly trained and well-paid men will more efficiently meet his requirements, while to the draughtsman the raising of the general level of professional training will automatically raise the status of the profession and at the same time provide an unassailable argument in favour of more adequate remuneration. Based on a comparison with the earnings of such trades as riveters, platers, &c., in pre-war days the earnings of draughtsmen as a class were in every way inadequate, and the discrepancy is now, owing to the frequent rises secured by labour, still more marked. Bearing in mind the study which is necessary to the training of a first-class draughtsman, both during and subsequent to his apprenticeship, the fact that a certain social position must be maintained in view of his staff position, and the extent of the knowledge which he requires to have of all trades, it is quite unreasonable that his earnings should be relatively so small. It is of course a peculiarity of Britons that they put the monetary rewards of brain work on an absurdly low plane, but it is of more than passing interest in this connection that at present, and for the first time, a very determined effort is being made by the Labour Party to enrol within its ranks all classes of brain worker.

For the realisation of the natural and legitimate aims of draughtsmen a well-considered and clearly defined policy, together with unity of action, are essential and to this end the formation of the Association of Engineering and Shipbuilding Draughtsmen is to be regarded as a most hopeful preliminary. The need for a strong and dignified professional organisation, having for its objects the promotion of the material and professional aims of the members, should be obvious to all draughtsmen, and the advantages to be derived from membership of such an association should be very great. There is considerable hesitancy on the part of many draughtsmen in joining any body which they consider to be analogous to a trade union—with the organisation and conduct of which, in their negotiations with employers, they have no sympathy. On the other hand there are not lacking evidences of a desire for an immediate alliance with and active participation in the methods of the trades unions. That such negotiations as may take place between representatives of the association and employers will be conducted with dignity in keeping with the aims of the association we do not doubt, and we feel sure that employers will recognise and appreciate this point, and while it may well be that the committee may deem it advisable to register the association as a trade union, it may be pointed out that this act will in no sense ally the association with existing trades unions—indeed, it may be noted that several of the employers' organisations are so registered. It is, however, from the activities in connection with the promotion of professional aims that we look for the permanent raising of the professional status. The field for individual and collective efforts is wide and the object worthy. The education and training of apprentices has already been made the subject of two papers read by members before a meeting of one branch of the association, and in these papers the desirability of instituting a professional examination for the association diploma and making the holding of this diploma an essential qualification for membership of the association is discussed. To many the institution of a professional examination will not

appeal, but the bearing of such an indisputable qualification on the status of members of other professional societies is too well known to require more than mention. The variety of professional subjects suitable for treatment and discussion in the form of papers is very extensive, and as no one can prepare, discuss, or listen to a well-thought-out paper without benefit we hope to see a very large extension of this form of activity and professional advancement. If at the same time the officials of the Association of Engineering and Shpibuilding Draughtsmen can convince the Ministry of Munitions of the inadequacy of the remuneration of their members, having regard to the services rendered to the nation, they will have gone a long way toward the elimination of the present unrest and will have accomplished something toward correcting the existing disproportionate scales of remuneration as between brains and brawn.

GERMAN AEROPLANE ENGINES.

The Royal Agricultural Hall at Islington will not be the scene this year of the usual Christmas show of livestock and agricultural machinery. The hall is not, however, wholly dissevered from its normal functions, as a part of the building has been devoted by the authorities to a small, but most instructive exhibition of captured German aeroplanes and engines. The object of the exhibition is educational, and for the convenience of manufacturers and others interested in aero-engine design, several engines have been dissected, and sets of the component parts, sectioned where necessary to show the construction, have been mounted on large boards, alongside specimens of the engines to which they belong. There are altogether some dozens of captured engines either officially on view, or rendered visible, by the courtesy of the attendants, to those interested. The aeroplanes, which are five in number, occupy another part of the hall.

Perhaps the most striking fact in connection with the engines is that, with a solitary exception, they are all of the vertical six-cylinder water-cooled type. German aero-engine design seems to have settled down along the lines of a straightforward racing-car engine, not perhaps of extraordinary lightness for the power developed, but reliable, durable and above all, easy to manufacture in quantities with ordinary labour and shop equipment. The one exception to this type is a specimen of a 100-h.p. Oberursel engine which formerly adorned a Fokker fighting monoplane. This engine is of the nine-cylinder rotary air-cooled pattern, almost indistinguishable from the Gnome rotary engine, which is largely used by the British authorities. It has the typical Gnome pistons carrying automatic inlet-valves in their heads, and in other features the resemblance is exceedingly close.

Reverting to the standard six-cylinder engines which really constitute the exhibition, these comprise the following types and sizes, namely, Mercédès 160 h.p. and 260-h.p.; Benz 160-h.p. and 220-h.p.; and Argus 120-h.p. and 200-h.p. The Argus engines differ from the others in the fact that the cylinders are in pairs, one sheet-iron water-jacket enclosing two cylinders, but as these engines have not yet been sectioned it is not possible to see the details of the cylinder construction. One of them is equipped with an English carburettor and English magnetos, and we believe that many captured German engines have been found thus equipped. It is said to be the German practice to design their engines to take British accessories and so to be able to utilise valuable fittings stripped from our machines which have come to grief behind their lines.

The Argus engines are also noticeable by reason of the amount of labour spent on the elaborate finish of unimportant parts. This is certainly not a typical failing of German engines, for these as a rule display a commonsense in the matter of finish, and of simplicity of detail, which our own manufacturers might emulate with advantage. On the whole, in so far as it can be inspected, the Argus engine does not appear to have any extraordinary merits, while in certain details, such as the use of loose cams secured by taper pins, the design is anything but commendable. On the whole, one probably would not be far wrong if he said that an equally good, or better, engine could be made for less money.

The real interest of the exhibition to designers of aero-engines lies in the remaining types, the Benz and Mercédès. These appear to represent the outcome of German experience as to what an aero-engine ought to be, at any rate for such work as long-distance bombing flights if not for more spectacular duties. The Gotha biplane carries two 260-h.p. Mercédès, the A.E.G. is similarly equipped, and the Rumpler biplane is fitted with a single engine of the same power and pattern. Benz engines of 220-h.p. are carried in the Aviatiks and the Agas. The Albatross two-seater carries a 160-h.p. Mercédès.

The Benz and Mercédès engines are, broadly speaking, of the same general pattern, each having six independent vertical water-cooled cylinders, with sheet-iron welded jackets, and both representing the final development of their racing-car prototypes. They weigh, we understand, about 3.75 lbs. per normal brake horse-power at ground level, this figure comprising a complete engine, but without radiator, fuel, oil, or tanks. Of the two the Benz is slightly the lighter per brake horse-power, and from the manufacturing point of view the details of its design are generally preferable to those of the Mercédès. The 160-h.p. Mercédès aero-engine of pre-war days had cylinders in pairs, like those of the Argus, and the crankshaft was also of peculiar design, but these features have been abandoned in the modern engines.

Dealing with the points of difference, the Benz cylinders are of cast-iron with solid valve-seatings arranged vertically in the head, whereas the cylinders of the Mercédès are of steel with exhaust and induction ports screwed in at an angle. In both sizes of the Benz engine the inlet and exhaust valves are duplicated, and are operated by a camshaft housed in the crankcasing. In the Mercédès engine a central overhead camshaft is adopted and duplicate valves are only used in the larger size. The casing of this camshaft appears a very costly piece of work, and the Benz design seems unquestionably better. The Benz pistons are of cast-iron, with three rings at the top and no scraper ring. A perforated steel cone is riveted to the inside of the piston-head, the apex of the cone forming a small seating on the centre of the gudgeon-pin. The function of this cone is probably to assist the lubrication of the pin, although the support it affords to the latter may be useful. The piston of the Mercédès is formed by screwing a steel head, carrying the gudgeon pin bosses, into a cast-iron skirt. The design of the connecting-rods also shows considerable difference. The Benz rods are of parallel tubular form, involving only lathework of a simple kind, whereas the Mercédès rods are of the usual I sections which gives greater trouble in machining.

Coming to the crankcase, in both engines the lower half of the case forms a support for the crankshaft so that the bearings and connecting rod-ends are very inaccessible when the engines are erected. This would appear to be an objectionable feature of both designs, unless it has been found that sufficient rigidity is not obtainable otherwise. There are no ball-bearings for the crankshaft of either engine, except for the thrust bearings. Oil cooling is arranged for on the Benz engine by a number of horizontal tubes passing transversely through the sump. A cowl on one side of the casing directs air into the tubes, and a similar cowl on the other side, facing backwards assists the draught through them. In the same engine the crankshaft bearers are also cored transversely from side to side, so that the air-circulation may tend to cool the bearings, and through two of these ports the air is drawn to the carburettors. The induction-pipe system of the Benz compares favourably with that of its rival and the water circulation system seems pronouncedly superior. On the other hand the circulating pump of the Mercédès, with its shrouded impeller and volute discharge is of much superior design to that of the Benz.

The general impression left on the mind by an inspection of the captured engines, is that the Germans have carried the standardisation of type infinitely further than we have, and therefore have placed themselves in a position to manufacture aero-engines with the maximum rapidity and cheapness. We have certainly captured many hundreds of German engines, and it is only reasonable to suppose that the collection at the Agricultural Hall is fairly representative of the bulk of those now used against our troops in Flanders and our civilian population at home. It is therefore a matter for remark that, except for the solitary Gnome engine, the Germans appear to have abandoned, or never to have used, the rotary type, the radial fixed type, the Vee type, the opposed type or the Broad Arrow type, not to speak of the numerous variants which each of these types comprises. They pin their faith, apparently, to a simple engine with the minimum number of parts, and devote their energies to increase of numbers rather than to the development of types. That "it is lawful to learn from the enemy" is a maxim as old as the art of war, and though our designers might gather some useful lessons from the engines exhibited, and notably from the Benz engine, we think that the most important lesson of all is to be learnt by reflecting upon the contrast between the present exhibition, and one which would be equally representative of current British practice.

DISCOVERY AND INVENTION.

That it takes all sorts to make a world is a popular precept, but the tolerant spirit of which it is the embodiment is often honoured rather by lip service than by practice, and in point of fact, as Wendell Holmes observes in one of his breakfast-table volumes, the abhorrence of the normal for the abnormal is by no means a wholly unhealthy instinct. Instinct uncontrolled by education and observation is, however, not always to be trusted, and though it might be successfully argued that the development of it which led to the condemnation of Galileo was sound from the inquisitor's standpoint, few now attempt to defend such artificial hindrances in the path of the scientific investigator, who is as necessary to the progress of mankind as any other section of the community. We have, of course, still people who object on principle to the use of anti-typhoid serum, and who refuse to recognise the extraordinary results of the treatment as exemplified during the past three years. On the other side we have certain scientific men, equally narrow-minded, who wholly fail to realise the wide gap which commonly exists between discovery and invention, and who complain that the inventor simply exists by picking the brains of those who are, they maintain, his betters. Tyndall observes that Faraday could, had he so chosen, have turned his scientific attainments to great pecuniary advantage, but the point is at least open to question, unless Faraday had become that not too admirable product of the nineteenth century—the professional expert witness. As Sir Dugald Clerk pointed out in the Trueman Wood lecture, delivered last week to the Society of Arts, discoverers are but seldom successful inventors. Of course, there are notable exceptions to this rule, of which the case of Lord Kelvin constitutes a shining example. The difference between the discoverer and inventor is largely the same as that between the pioneer and the settler. Admittedly, modern electrical engineering has as its basis the work of Faraday, but the commercial value of this work, as Faraday left it, was insignificant. Much thought had to be expended and much capital risked and lost before the path was clear to the construction of the modern electric generator. The discoverer of new concepts, even such as may revolutionise an industry, commonly loses much of his interest in the subject after his immediate aim is attained. He works largely for his own mental satisfaction, as is well exemplified by Cavendish, who, though recognised as one of the leading physicists in Europe, could with difficulty be persuaded to give any of his discoveries to the world. It was, again, only the insistence of Halley which secured the publication of Newton's "Principia." The inventor's mental attitude is in the main different, but, all sorts being necessary

to make a world, his function is certainly not less indispensable than that of the scientific investigator. The latter may pass sleepless nights and laborious days over his problems, but just as his material reward in case of success is less than that of the triumphant inventor, so also are his risks. Pallisy, the potter, used his furniture for his furnaces, being unable to purchase fuel. Similar stories could be told of the struggles of other inventors, which it would be impossible to parallel amongst those who pursue science for its own sake, although Herschell's early struggles were no doubt severe.

Sir Dugald Clerk rather demurred to the view that a higher order of mind was required for discovery than for invention, but much, of course, depends on the way in which the term discovery be defined. It is certainly true that the faculty of making useful generalisations in pure science is rarer than that of making useful inventions. Much scientific work is, however, of a low-grade order, requiring merely care and intelligence rather than insight. Such a research for example as that of Landolt and Heydweiler, on the constancy of mass in chemical reactions, important as the point at issue may be, lies on a distinctly lower level than that of Max Planck on the "quantum" of energy. Whether or no this conception be destined in its present form for a permanent niche in the temple of physics, Planck's work constitutes a contribution to scientific thought, whereas the measurements of Landolt were merely an addition to scientific data. Just as a higher order of intellect was required to write Shakespeare's plays than to compile a dictionary, there do seem grounds for the belief that our great scientific discoverers are intellectually superior to our great inventors. The trouble, of course, arises when the claim is not limited to work of the highest class. Though Shakespeare was no doubt intellectually the superior of Webster, to make the same claim for every playwright would be preposterous. Unfortunately, it is commonly the second-rate scientific man who is most insistent on the superiority of his calling to that of the worker in applied science, such as the engineer or industrial chemist.

Discoveries, though they may revolutionise an industry, are at their birth merely bills drawn on the future, and of a highly speculative character. It is not true in practice, as Professor Soddy once claimed, that an academical chemist could write down on half a sheet of notepaper data of such value as to maintain in comfort a whole class for a generation. The gulf between the laboratory and the factory is unfortunately by no means so easily bridged. Dr. Baekeland has observed that when he commenced to manufacture photographic papers he found that so far from there being but three or four varieties of silver bromide as asserted in the text books, there proved to be nearly 100; and he had by painful and expensive experience, to learn how to make with certainty the individual one of these many varieties, which had a commercial value. In another case instanced by him it took four years and an expenditure of 60,000*l.* to bring an electrolytic cell from the stage of a laboratory experiment to that of successful operation on a manufacturing scale. Were Professor Soddy right, there would be much to be said for the reluctance of many commercial men to accord to their scientific and technical advisers, the status which it is essential they should possess if our industries are to be successfully maintained.

The view that the possession of certain working rules and formulas was all that was necessary for the prosperous conduct of an engineering or chemical works has unfortunately been widespread in the past, but unless it be abandoned in favour of a more enlightened policy, it is difficult to see how our enormous war debt is to be liquidated. Unfortunately the signs of the times are none too favourable. Some millions of public money have been invested in British Dyes, Limited, and, according to Professor Armstrong, there is reason to believe that the really profitable and difficult operations are being carried out mainly abroad, the directors refusing to employ the scientific staff which would be necessary were the work to be done here. No doubt, much of the trouble originates in the narrowly specialised way in which most of our director class have been educated. It is, no doubt, true that business men have repeatedly been taken in and have lost large sums in following the advice of plausible but incompetent engineers or other technologists. In other cases, on the other hand, they have refused to continue experiments when success was fairly in sight. It would, of course, be unreasonable to expect every business man to be a scientific expert. The golf aspirant in *Punch* was advised by his teacher, that though he would never make a player, he might at least learn to recognise good golf when he saw it, and it is to be hoped that sufficient reforms will be made in the curriculum of our secondary schools as to make those who will direct our industries in the future at least able to distinguish the charlatan from the genuine expert. In the meantime the path of safety will lie in the appointment of experts to the directorate, making them partners in the business rather than mere subordinates.

As already observed the reward of the discoverer consists largely in the mental satisfaction attained. Few, however, if any, inventors would face the intense mental strain and the pecuniary risks involved in the practicalising and commercialising their ideas for this mental satisfaction merely. A discoverer may be content when he has firmly established his concept in its broad outlines, knowing that the details will be ultimately filled in by others. A new invention is, however, valueless unless developed to a stage in which it is complete in every detail. Large fortunes have been made out of the ammonia-soda process, but the original inventors lost fortunes, as it proved impossible for them to solve satisfactorily certain minor, but all-important, practical problems. The social reformer who looks forward to an equality of reward between the day labourer and the man who, like Bessemer, increases the wealth of the world by some 100 millions per annum (as has been estimated by an American economist) is singularly blind to the teachings of experience. Such schemes have repeatedly been tried, and failure has been the inevitable result. The story of the labourers in the Vineyard, where equality of reward was the lot of those who came in at the eleventh hour and those who had borne the heat and burden of the date, stops at the critical point. It would have been of interest to have learned what happened when the vineyard proprietor in search of labour made his next appearance at the "buchs," if the use of the Scotch term be permissible. To some extent, of course, our Government departments have been run on a basis not essentially different. The emolument has been fixed for the office and not for the man, and the careful routine worker obtains the same reward as would the most brilliant and original genius and with greater certainty. Every official's ideal is, therefore, to avoid responsibility. If he ventures to father an innovation, his possible reward is at best far too small to make the risk worth while, and he conceives it his duty to himself to be safe rather than sorry. In the present crisis this policy has been wellnigh disastrous. Not a single practical engineer has so far said a good word for the permanent official, whilst others have bluntly declared that their steady obstruction is "losing us the war." State arsenals, State railways and State telegraphs have contributed little or nothing to the advance of manufacturing methods or improvements in transport or in methods of communication. A Government official may perchance be a discoverer, but he has little inducement to face the trials and tribulations associated with the "practicalising" of an invention.

THE VISCOSITY OF BLAST-FURNACE SLAG AND METALLURGY.

The determination of the viscosity of blast-furnace slag has much more than a theoretical interest. Broadly speaking the slags are complex silicates such as Nature has provided in astounding variety; man has further extended this variety by the manufacture of glasses and enamels. One common property of silica and those complex silicates (alkaline feldspars, especially) is that they do not possess a definite melting-point; they gradually soften and become more fluid as the temperature is raised. The mobility of the molten mass must influence the subsequent solidification and the crystallisation of definite compounds; hence the interest of mineralogists and geophysicists in the viscosity problem. The metallurgist has to smelt his ores with the aid of fluxes which afterwards form slags floating on the metal, and the slags play an important part in the reactions on which the purity of the metal depends. For these reactions the metallurgist wants a limpid slag. Until quite recently, however, he had no experimental knowledge at all of the real viscosity of slags of different compositions at different temperatures, and the fact that the constituents of some complex silicates, silica and refractory oxides, enter into the materials, from which suitable vessels for such determinations are made, rendered these experiments particularly difficult. We drew attention, on page 484 of our issue of May 18, 1917, to the way in which the difficulties of conducting viscosity measurements at temperatures at which iron is liquid have, for the first time apparently, been faced in the Pittsburg laboratories of the United States Bureau of Mines by Messrs. Alexander L. Feild and F. H. Willcox. The subject was brought before the Faraday Society last Wednesday in a communication by Mr. Feild, on "The Viscosity of Blast-Furnace Slag and its Relation to Iron Metallurgy."

Blast-furnace men know that the slag is more viscous than the molten iron underneath it. The high viscosity and the gradual softening, Mr. Feild pointed out, seemed to be due to the silica, and not to the alumina and other oxides present, and to the silica itself, and not in general to silicon compounds. That may be so; but all substances soften before actually fusing, and our scanty knowledge of the behaviour of pure refractory materials hardly admits of such a general statement. It is, however, interesting that, according to Bragg, the silicon and oxygen atoms of silica are not arranged separately at definite points of a space lattice, but that silica molecules are associated with each point of the space lattice. In the case of liquids, highly associated or polymerised molecules seem to be characteristic of high viscosity; similarly the association of several molecules may be the fundamental cause of the high viscosity of the silica and silicates. In making this suggestion, which is based on the X-ray examination of crystal structure, Feild also dwells on the recent considerations concerning the constitution of solids and liquids which Irving Langmuir published last year. Distinguishing with Werner and others between primary valencies and residual valencies, Langmuir concludes that the molecular weight has little significance even in the case of a liquid. We cannot on this occasion follow Mr. Feild in these speculations; but we will, with him, consider the importance of the viscosity of a slag with respect to fuel economy and metallurgical operations.

While it is theoretically possible to render any silicate mixture sufficiently fluid to flow from the cinder notch of a blast-furnace, it is in practice necessary that the slag attain this fluidity at a temperature which is not beyond the working limit of the furnace lining and which does not demand an excess of fuel. Suitable fluxes can generally be found for all kinds of ore; but their compositions have to be studied, and each furnace has its own peculiarities. The slag fluidity desirable for smelting and for purity of metal is not merely a question of a certain number of heat units; a certain temperature must be attained. Though that point was understood, it used tacitly to be assumed that the reaction $C + O \rightleftarrows CO$ could be relied upon to yield sufficient heat near the tuyeres. The coke is not fed with oxygen, but with air, of course, and in the air the oxygen is diluted, not only with a steady percentage of nitrogen, but also with an amount of moisture which fluctuates from hour to hour and in the ratio of 1 to 4 or 5 in the course of a year. When Gayley proved at the Isabella furnace of the Carnegie Steel Company, in Pittsburg, in 1904, that the puzzling fluctuations in the grade of iron from the same furnace were frequently due to moisture fluctuations, and not to changes in the quality of the coke, and that a dry blast, sent through an ammonia refrigerator, secured a uniform, much-improved output of metal, the real reasons for the improvement were for a long time disputed.

A. Lodin, Feild points out, seems to have been the first who recognised that the adequate fusion of the slag required a certain minimum temperature and a certain number of calories which were taken up at the expense of what J. E. Johnson called the available hearth heat and critical temperature. The Bureau of Mines and Mr. Feild are now investigating the available heat problem with special regard to the functions the slag is to perform. The main chemical functions of the slag is to desulphurise the iron, which has combined with the sulphur of the coke to form ferrous sulphide. It is not certain that the desulphurisation proceeds even broadly in accordance with the largely accepted formula: $FeS + CaO + C = CO + Fe + CaS$, that is to say, that the lime takes up the sulphur; it may be that the aluminates, dissolved in the silicates of the slag, really act as desulphurisers, as T. Turner (1905) and Schäfer (1913) have suggested. In any case, the reaction will only take place at the interface between iron and slag, and the resulting sulphide, probably CaS, must be able to diffuse rapidly from the iron so as to prevent the reversible reaction from coming to a standstill prematurely. That condition calls for a mobile slag, and would do so also, if there should be noteworthy reaction between the iron globules, as they sink to the bottom of the hearth, and the contiguous layer of slag. Now the experiments to be described show that the viscosity of a blast-furnace slag at 1,500 deg. C. may range from a good average value of 250 (taking the viscosity of water at 20 deg. C. as unit) up to 1,000 and even 3,000; those figures sufficiently illustrate the importance of the research.

In the first instance Feild ascertained in how far Seger cone tests would afford information as to the viscosity of the material out of which the cones had been shaped. Ceramically it will frequently be quite sufficient to determine the temperature at which a certain mixture softens and begins to flow. That softening temperature is by no means a criterion of the viscosity of the material, however, it results. In mixtures of slag composition, which are never high in silica in the same sense as refractory materials are high in silica—when they consist essentially of silica—low softening temperatures and high silica contents go together. For commercial slags 36 per cent. of silica is probably a fair average. Mr. Feild examined 18 such slags; our Table I is an abstract of Mr. Feild's table; the first column indicates the percentages of the constituents; the last column states the softening temperature in degrees Centigrade.

TABLE I.—*Softening Temperatures of Slags.*

	SiO_2.	Al_2O_3.	Fe_2O_3.	TiO_2.	CaO.	MgO.	MnO.	CaS.	Deg. C.
	48.0	8.0	—	—	32.0	5.0	0.1	2.0	1,244 to 1,254
F	43.6	9.5	0.59	0.19	40.2	2.1	0.2	2.8	1,279
E	37.2	11.5	0.42	0.52	25.3	19.6	2.2	3.5	1,297 to 1,300
C	33.7	26.6	0.79	0.28	26.7	6.4	0.33	4.9	1,342
D	34.3	13.8	0.35	0.56	41.3	6.4	0.55	5.4	1,343 to 1,360
A	18.3	35.3	0.52	0.58	31.2	9.7	0.35	4.1	1,410
B	31.5	14.8	0.29	0.29	47.6	1.8	0.2	3.6	1,403 to 1,443

We leave out the alkali percentage (about 0.5) and the moisture percentage (about 0.1) which were not determined for all the slags. There is some doubt about Mr. Feild's iron percentages. The atmosphere in his carbon-resistance furnace was reducing, consisting essentially of carbon monoxide and nitrogen as in such furnaces generally, and in some cases he observed globules of molten iron. He, therefore, distinguishes in his analyses between Fe, FeO and Fe_2O_2; but his figures do not accord owing to some mistake, and we give, therefore, what is apparently the total iron calculated as Fe_2O_3. With the exception of the first slag mentioned, the same slags afterwards served for the viscosity tests; the letters A, B, C, D, E, F mark the slags used in those tests as tabulated lower down.

We see that slags containing up to 48 per cent. of silica, which are known to be more viscous at furnace temperatures than more basic slags, possess a paradoxically low softening temperature. The softening, it would appear, depends upon the amount of eutectic mixture formed during incipient fusion; but when the softening temperatures stated are exceeded by, say, 200 deg. C., the one mixture may have a viscosity three times as high as the other of about the same softening temperature.

With the co-operation of Dr. J. K. Clement, Mr. Feild also attempted to determine the temperatures of the slag at flush, by means of a Holborn-Kurlbaum pyrometer A, and of a thermocouple B. Since a stream of slag does not fulfil black-body conditions, the A and B values in degrees Centigrade differed widely, *e.g.*: A, 1,487, 1,487, 1,465; B, 1,470, 1,575, 1,525; the use of the optical pyrometer was therefore discarded—these features were quite recently discussed by the Faraday Society, see ENGINEERING, pages 497, 527, 539 *ante*—and only thermocouple readings were taken later. A slag with 35.2 per cent. of SiO_2, 12.1 per cent. Al_2O_3, 43.7 per cent. CaO, gave an average flush temperature of 1,500 deg. C., another slag (37.6 per cent. SiO_2, 12.46 per cent. Al_2O_3, 40.8 per cent. CaO) gave 1,485 deg. C.; the slags differed little in composition otherwise.

We pass to the viscosity determinations. The method used was, as we explained in our Note above referred to, that of Margules. The liquid to be examined is confined between two concentric cylinders; the outer cylinder is slowly rotated at a constant rate, and the torque exerted upon the inner cylinder is measured; this torque is $4 \pi \eta L \omega a^2 b^2 / (b^2 - a^2)$, where η is the viscosity to be measured, L the common length of the two cylinders of radius b (outer cylinder) and a (inner cylinder), and ω the angular velocity of the outer cylinder. As this velocity was very small in the experiments, about 1 revolution per second, the question of a possible slip at the boundary plane between the outer cylinder and the liquid could be disregarded. The two cylinders were a crucible, $\frac{3}{4}$ in. diameter and 3 in. high (internal dimensions), and a spindle, $\frac{1}{2}$ in. diameter, 1 in. high; the material was in both cases Acheson graphite which, it was proved, remained practically unattacked by the fused slag. Since it was impossible to give the two cylinders the same length, an end effect did arise; by experimenting with inner cylinders or spindles of the same diameter, but of different lengths, this effect was compensated for. The real spindle formed the lower end of a shaft of graphite, 5 in. long, which was screwed into a connecting rod, likewise of graphite, fitted above with a steel collar; into this collar was screwed the suspension rod of steel, which was attached to a steel ribbon, 0.15 mm. thick, 1.68 mm. wide and 4.2 cm. long. Immediately underneath the ribbon a mirror was attached to the rod which, further below, carried a weight of 200 grammes and a horizontal arm, fitted with damping vanes at its extremities. The suspension system was weighted, lest it should float in the molten slag, and it was made long in order to remove the steel ribbon and mirror out of the hot zone. The crucible was mounted on the top of a vertical shaft (turned through gearing by an electric motor), so as to be in the middle of a tubular electric furnace, 3 in. internal diameter, 6 in. high; the furnace consisted of two concentric alundum tubes, wound outside with resistance to heat the granular carbon resistance between them. In an experiment the crucible was charged with about 175 grammes of powdered cold slag which, fused, would fill half the cylinder. When the slag began to melt, the suspension system, so far raised, was lowered so that it rested on the bottom of the crucible ($\frac{1}{4}$ in. thick) for a moment; it was then raised again so that the spindle was 5 mm. above the crucible bottom, and the crucible was rotated, while it was gradually being heated up to 1,500 deg. or 1,600 deg. C., and allowed to cool again. Observations were taken during heating and cooling over the range 1,275 deg. to 1,575 deg. C.; these temperatures were determined with the aid of the optical pyrometer sighted on the fused slag; the conditions were black-body, but the fumes from the slag may have disturbed the observations.

The results are tabulated in Tables II and III; the viscosity unit is the viscosity of water at 20 deg. C., and the letters A, B, C, D, E, F refer to the compositions of the slags stated in Table I. In Table III another series of heating and cooling experiments with slag C is recorded, the viscosity values referring to rising temperatures and to falling temperatures.

TABLE II.—*Viscosities of Blast-Furnace Slags (Water = 1).*

Temp. Deg. C.	Slag A.	B.	C.	D.	E.	F.
1,275	—	—	—	1,400	—	—
1,300	—	—	1,700	1,000	1,900	—
1,325	—	—	1,060	820	1,100	3,000
1,350	2,600	—	800	680	840	1,800
1,375	1,150	—	640	540	640	1,220
1,400	750	3,000	510	460	510	1,000
1,425	540	580	420	400	440	820
1,450	410	480	350	310	380	680
1,475	320	415	300	310	320	580
1,500	230	380	260	280	280	480
1,525	160	340	225	250	240	400
1,550	—	290	—	220	—	340
1,575	—	—	—	—	—	310

TABLE III.—*Viscosity V with Rising and Falling Temperatures T. Slag C.*

Temperature T Deg. C. Rising.		T Falling (Order Reversed).			
T.	V.	T.	V.	T.	V.
1,382	605	1,292	1,940	1,382	611
1,410	513	1,297	1,707	1,387	524
1,415	460	1,302	1,505	1,425	446
1,425	442	1,312	1,319	1,440	375
1,463	320	1,322	1,074	1,466	323
1,473	291	1,337	922	1,470	304
1,510	255	1,350	805	1,488	285
		1,359	728	1,525	228
		1,368	687		

When the viscosities were plotted against temperatures, the curves were approximately rectangular hyperbolas, and the fluidity curves (fluidity being the reciprocal of viscosity) hence nearly straight lines. Assuming the average temperature of a slag at flush to be 1,500 deg. C., the viscosity of a normal slag would approximate the value 250 at that temperature, that is to say, the slag viscosity would be a little greater than that of olive oil and a little smaller than that of castor oil. The viscosities of the eight slags examined varied from 230 up to 480 at 1,500 deg. C., the average being 300. Another synthetic slag (48 per cent. silica) showed a viscosity of 770, while an artificial diopside ($2SiO_2CaOMgO$) containing 55 per cent. of silica, showed the viscosity 640, all at 1,500 deg. C. Thus really high silica percentages increase the viscosity, even in the absence of alumina; but the relations cannot be expected to be simple, as has been already pointed out. The following table of softening points and viscosities at three high temperatures will further illustrate this feature:—

Slag.	Softening Temperature, Deg. C.	Viscosity at		
		1,400	1,450	1,500
F	1,279..	1,000	680	480
E	1,297 to 1,300	510	380	280
C	1,342..	510	350	260
D	1,343 to 1,360	460	350	280
A	1,410..	750	410	230
B	1,403 to 1,443	3,000	480	380

Slag A contained 35.3 per cent. of alumina; it will be seen that it had a high softening temperature, but not a high viscosity at high temperatures. On the other hand, the substitution of 20 per cent. of lime by an equivalent amount of magnesia in another synthetic slag caused a diminution of the viscosity, especially at the relatively lower temperatures between 1,250 deg. and 1,350 deg. C.; the lime slag still had, at 1,350 deg., a viscosity of 800, which the magnesia slag already possessed at 1,280 deg.; at 1,350 deg. the viscosity of the magnesia slag had gone down to 400. It will require much systematic experimenting to establish relations between the fluctuating slag compositions and their viscosities.

NOTES.

A DEFECT IN OUR PATENT LAWS.

IN his recent presidential address to the Institution of Civil Engineers of Ireland, Professor W. E. Lilley drew attention to a difficulty which sometimes arises in connection with improvements in engineering processes and products. If these are entirely novel, the patent laws afford the inventor protection, whilst the introducer of new external forms can secure himself by registration. There are, however, numerous cases in which it may prove

impossible to adequately protect quite important improvements in engineering practice. The general idea underlying these may perhaps have been embodied in the specification of some dead and gone inventor who quite failed to bring his plans to fruition, or it may have been discussed purely from the academic standpoint in some theoretical treatise. In such cases the engineer who finally bridges the difficult gap between a project on paper and a machine of commercial value is very likely to have merely his trouble for his pains, as it would be impossible in the conditions stated to secure a master patent. A notable instance, in which fortunately those concerned did secure a fair reward for their enterprise, is afforded by the history of the pneumatic tyre, which as soon as it was proved valuable was found to have been anticipated some forty or fifty years previously by an inventor, who found it impossible under the conditions of his day to find a market for his highly important improvement. The major portion of Dr. Lilley's address was devoted to an historical discussion of rotary pumps and engines of the internal gear type, as to the possibilities of which he expresses somewhat sanguine views.

A Large Electromagnet.

For the study of magnetic phenomena of anisotropic liquids, also at low temperature, Dr. The Svedberg, of the University of Upsala, Sweden, had a large magnet constructed by Messrs. J. L. Rose, of the same city, which is interesting for its size, power and simple construction. It consists of a rectangular frame, 77 cm. by 55 cm., built up of four bars, the cross-section being 15 cm. by 7.5 cm. The frame is fixed to a cast-iron base, and the magnet can either be used with the frame vertical, when the magnetic axis is horizontal, or with the frame horizontal. The two pole-pieces are cylindrical and face one another, being bolted to the inner sides of the short sides of the frame; each pole-piece has a diameter of 14.7 cm., a length of 23.5 cm., and is provided with an axial bore, 12 mm. in diameter. The windings of each pole-piece consist of six cylindrical coils, fitting over one another; the coils are separated from one another by water jackets, the water circulating through the brass jackets in a zig-zag. There are four layers of wire in each partial coil, and no layer is more than 6 mm. from one of the water jackets. The copper wire of the windings has a diameter of 2 mm., and as the continuous current supply of Dr. Svedberg's laboratory is at 450 volts, and as there are about 4,500 turns of wire of a resistance of 20 ohms, he can work with currents of 20 amperes. The whole magnet can be suspended by a hook. The weight of the base is 102 kg., the frame weight is 262 kg., that of each pole-piece 10 kg., of the coils 115 kg. per pole, giving a total weight of about 600 kg. Transport is facilitated by having the magnetic system separable in six parts. The pole gap can be varied between 2 cm. and 8 cm., its diameter between 3 cm. and 14.7 cm.; with an air gap 2 cm. long, 3 cm. in diameter, a maximum field intensity of 21,500 gauss can be obtained. The construction of this electromagnet, which is illustrated in the *Annalen der Physik* of July 17, 1917, is much simpler than that of the powerful magnets which Pierre Weiss and H. Du Bois use for their researches.

The New Trade Development Department of the Government.

We are glad to record progress in connection with the development of the new department instituted by the Government for the promotion of our overseas trade. It is somewhat of a hybrid, being under both the Foreign Office and the Board of Trade. Generally, such dual control is undesirable, but, as we pointed out when the new department was decided upon, duality is inevitable, because commercial affairs in the future will involve questions of international politics more frequently even than in the past. The disadvantages of duality can be overcome by the discretion and ability of the chief of the department. Sir Arthur Steel-Maitland, Bart., M.P., has been appointed to this office, and is designated Under-Secretary for Foreign Affairs and Parliamentary Secretary to the Board of Trade, so that he is the link between the two Government departments. Since his appointment considerable progress has been made, and now the new department has absorbed (1) the Commercial Intelligence Branch of the Board of Trade, (2) the War Trading Branch of the Foreign Office, which was created to deal with the problem of the blockade and other Admiralty questions, inevitably opening up various economic matters which will extend to peace negotiations, (3) the Foreign Trade Department of the Foreign Office, which deals with the statutory list of enemy firms in neutral countries, and with the development of British businesses now being evolved to supply the manufactures formerly undertaken by such enemy firms and generally to encourage constructive business by friendly firms and organisations, and (4) the consular services and the whole consular department of the Foreign Office. Sir Arthur Steel-Maitland, in making a statement of progress, indicated that the overseas division of the work would be organised geographically. Already the number of Trade Commissioners who undertake work in connection with the Empire has increased from four to sixteen, and the salaries to be paid will range up to 1,200*l.* per annum, with certain additions for travelling and other expenses, exclusive of office staff and office allowance. The commercial representatives in foreign countries—whether to be known in the future as *attachés* or not, has not been decided—will also be increased in number, and it is probable that their remuneration will be 1,500*l.* per annum, but under certain circumstances allowances may increase this to as much as 2,500*l.* per annum. This higher remuneration is due in part to the variations in foreign exchange, and other conditions incidental to a foreign country. Definite standard salaries have to be fixed for pension purposes, but allowances to meet special expenditure are made to overcome variations in the different countries. The commercial representative in foreign countries will take much higher rank in the diplomatic service than hitherto. In addition, there will be the consular officers, who ordinarily will communicate directly with the department in London; although, in matters common to all consuls in a country, they may also communicate with the chief commercial representative in the country in which they act. The officers overseas are expected to take a much wider view of assistance to British manufacturers than in the past, and we hope the result will be more in accord with this expectation than the realisations of past years. There is a desire, too, to expedite communication. In this country the division of the departmental work will be according to trades. An Advisory Council is to be formed, representing all interests, and it is hoped that our industries will be so organised as to provide means of communicating their desires to the Advisory Council or the department direct. Sir Arthur has stated that the department has no desire to eliminate the merchant in commercial affairs. He himself considers that any such policy would not be conducive to the manufacturing interests of the country, as there are large spheres of foreign trading in which the merchant must continue to be important.

Coal-Gas for Motor Cars; 1,000*l.* Prize.—The Automobile Association Executive Committee has decided to offer a prize of 1,000*l.* for the best invention which will enable coal-gas to be used with advantage as a propellant of motor cars and motor cycles. A small sub-committee has been formed to prepare the conditions, which will be announced in due course. The sub-committee will gladly consider suggestions, which should be addressed to the Secretary, Automobile Association and Motor Union, Fanum House, Whitcomb-street, London, W.C. 2, and marked "Coal-Gas."

Locomotive Construction in Spain.—It has been stated that the Spanish railways were on the point of forming a company for undertaking the construction of locomotives in Spain. The scheme is a real one, says *Revista Minera, Metalurgica y de Ingenieria*, Madrid, but it does not apply to the formation of a new company. The intention is to increase the capital of the Maquinista Terrestre y Maritima Company, which has already built locomotives, as is well known, and which owns the staff and the means for this industry. In any case, the new capital will be used for the industry in question. The increase in capital is to be about 15,000,000 pesetas (about 600,000*l.*). The Madrid, Saragossa, Alicante Railway has subscribed an important part of this sum.

The Late Mr. Ewing Matheson.

We regret to have to record the death, which occurred on the 7th inst., at Stapledon House, Dartmouth, of Mr. Ewing Matheson, the well-known engineer and author of several books on civil engineering. Mr. Matheson was in his seventy-eighth year, and had been a member of the Institution of Civil Engineers since May 2, 1876.

He served a seven years' apprenticeship course at Mr. Andrew Handyside's works, Derby, following which he entered for a time Mr. Laird's shipbuilding and marine engine works, Birkenhead. Mr. Matheson established a private consulting engineer's practice in London, in 1863, whence shortly after he managed the London and export business of Messrs. Andrew Handyside and Co., Derby, in which firm he had been appointed a partner. In this connection he was actively associated in all the large civil engineering undertakings successfully carried out by the Derby firm. The latter was transformed into a limited liability company in 1873, and Mr. Matheson was made one of the directors. In the same year he established, in partnership with Mr. R. C. Grant, under the style Matheson and Grant, a consulting engineering practice in London, which for a long period carried out important civil engineering work for railway companies, harbour boards, municipalities, both at home and overseas. He resigned his position as director of Messrs. Andrew Handyside and Co., Limited, in 1903, though he still retained an interest in the firm.

Among the books published by Mr. Matheson, we may mention "Works in Iron, Bridges and Roof Structures," first issued in 1872. Then followed, in separate parts, published from 1878 to 1881, his "Aid-Book to Engineering Enterprise," in which, he stated, he had endeavoured to classify and link together the technical and economic conditions which determined the success or failure of public works and engineering ventures; in this book he also called attention to the various modes of making contracts and to the conditions necessary to the choice and purpose of engineering material. A third work of his, published in 1884, was entitled "The Depreciation of Factories and their Valuation."

Mr. Matheson received a Telford premium for a paper he read before the Institution of Civil Engineers on "Steel for Structures."

Mr. Matheson was also a director, since 1887, of the Farnley Iron Company, Limited; his business activities brought him into close touch with the West Riding of Yorkshire, and whilst in Leeds he was a prominent member of the Leeds Chamber of Commerce; he was for many years a member of the Council of that body. He became Vice-President of the Chamber in 1897, and filled the office of President during the two years following. In 1905, he was nominated an alderman of Leeds, and was made chairman of the Electricity Committee. He held this office for three years, until the committee was amalgamated with the Tramways Committee, when he was appointed Vice-Chairman.

The Bahia Blanca Dock.—We read in the *Rivista Marittima*, Rome, that the new masonry basin at the military harbour, near Bahia Blanca, the largest in South America, is completed and has been successfully tested. Its principal dimensions are the following: Length, 183 m. (600 ft.); depth to the sill at the entrance, 9.75 m. (32 ft.); width at the entrance, at the base, 35 m. (114 ft. 10 in.), at top, 36.67 m. (120 ft. 4 in.).

Lignite Distillation.—The distillation of lignite, as practised in Saxony and Thuringia, differs from ordinary coal distillation, and is essentially a low-temperature process. The brown coal, as it is called, is heated to 200 deg. C. for about 24 hours under slightly reduced pressure. The products are: Tar and oil, 6 per cent. to 8 per cent.; tar-water, up to 50 per cent.; gas, 12 per cent.; coke, up to 36 per cent.; the refining of the tars and oils yields creosote oil, paraffin (hard and soft), lamp and cleaning oils, and solvent oils commercially known as benzine; the ammonia is utilised as fertiliser. The coke does not cake, but makes a good fuel when briquetted. As much of the coal of the Western United States, especially of the State of Washington, is of lignite type, Messrs. H. K. Benson and L. L. Davis, of the Washington State University of Seattle, made some experiments (*Journal of Industrial and Engineering Chemistry*, October 1, 1917, pages 946 to 949) on tars from lignite, which is at present only burnt locally as steam coal in locomotives of special design, though it can be transported in closed cars. The retort used was a 3-in. gas pipe wound with nichrome wire; it was heated for 24 hours at atmospheric pressure. The rough yield of gas increased from 1,900 cub. ft. per ton at 200 deg. C. to 9,800 cub. ft. at 600 deg. C. Considering all the products and especially the oils, a distillation temperature of 380 deg. C. seemed to be the most profitable. The raw oils made up 5.5 per cent. of the coal weight, and they resembled petroleum and shale oil more than they resembled coal-tar oils, benzol and its derivatives being absent; the oils seemed suitable for lubrication, for engine fuel and lamp oils, and for solvents. Some wax was obtained, and the coke was a good fuel. Further experiments are to follow.

2,000 I.H.P. TRIPLE-EXPANSION MARINE ENGINES.

CONSTRUCTED BY MESSRS. McKIE AND BAXTER, GOVAN, GLASGOW.

FIG. 1.

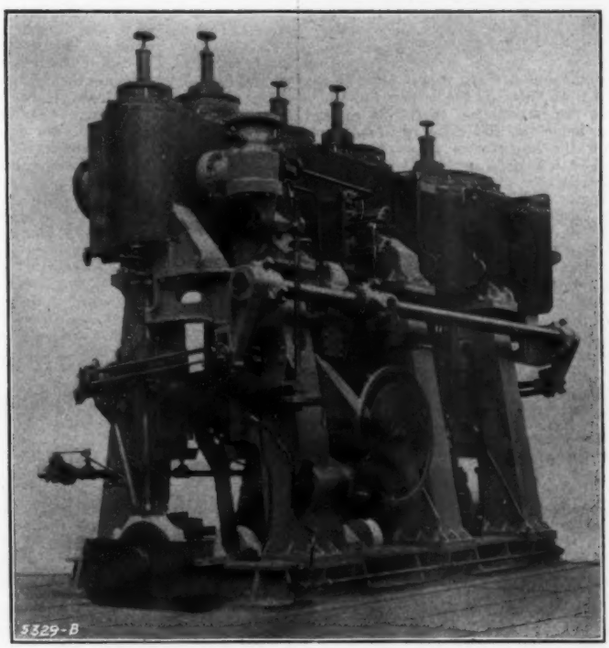

FIG. 2.

THE above reproduction of photographs illustrate a set of twin-screw marine engines of 2,000 i.h.p. constructed for the Admiralty by Messrs. McKie and Baxter, of Govan, Glasgow, under somewhat exceptional conditions. Messrs. McKie and Baxter inform us that the terms of contract stipulated that the engines were to be finished and ready to leave the shop in eight weeks from the date of order. The design of the engines was left to the makers, and patterns and drawings of similar engines were in existence, but these had to be considerably altered to meet Government requirements. Otherwise, on the date of order nothing had been done or prepared.

The engines are of the triple-expansion type, with cylinders 13 in., 23 in. and 36 in. in diameter, with 21 in. stroke. The boiler pressure is 200 lb. per square inch, and the engines indicate 2,000 h.p. when run at 200 r.p.m. The general design is shown clearly by the illustrations above. Of these, Fig. 1 shows the condition of the engines at the end of seven weeks from the date of order, no night shifts having been worked, while Fig. 2 shows the starboard engine completed at the end of the eighth week. We may add that eight engines of the same pattern have since been finished or are in process of construction by Messrs. McKie and Baxter for the Admiralty.

THE LATE MR. LEWIS ENFIELD TAYLOR.—We regret to have to announce the death, which occurred abroad on the 3rd inst., after an operation following enteric, of Mr. Lewis Enfield Taylor, Madras and South Mahratta Railway, and Captain of the Madras Volunteer Corps. Mr. Taylor was an Associate Member, since December 1, 1908, of the Institution of Civil Engineers.

INDUSTRIAL NOTES.

WE are officially informed that a report which recently appeared in the press (not in ENGINEERING), on the authority of the National Alliance of Employers and Employed, to the effect that a Parliamentary Committee was to be appointed to give effect to the proposals of the Whitley Committee, is inaccurate. We understand that a Committee, including some Members of Parliament and representatives of organisations favourable to these proposals, has been in contemplation, but that its object was simply to make them known, and so far as possible to commend them to employers and workmen.

The Government have decided to apply, with effect from the beginning of the first full pay next after October 12, the 12½ per cent. Time-Workers' Bonus to all men of 21 years or over working on munitions work in engineering shops, foundries or boiler shops, who are in the employment of owners of federated shops of that class, to which the general awards of the Committee on Production in the Engineering and Foundry Trades have applied, or of owners of shops or foundries to which those awards have been applied by Order made by the Minister of Munitions, and to all men of 21 years or over while engaged on shipbuilding or ship-repairing work being munitions work, who are in the employment of a shipbuilding or ship-repairing establishment, provided that the men are paid as plain time-workers, and provided (in the case of engineering shops, foundries or boiler shops) that their wages have been regulated by the movements in the wages of men employed in the engineering and foundry trades. The bonus is not payable to skilled woodworkers employed on aircraft (except in a shipbuilding or ship-repairing establishment) for whom a standard rate is to be fixed under an Order to be made by the Minister of Munitions. Orders will be issued by the Minister of Munitions in due course to all establishments affected by this decision, so that payment may be made on the pay day during the week ending December 22.

The Minister of Labour has appointed the following to act as the Central Advisory Committee for the Iron and Steel and Kindred Trades (Operatives), which will advise and assist the Minister of Labour on questions arising in the administration of the Employment Exchanges, which affect workmen in those trades: Councillor Ivor H. Gwynne, J.P. (Tin and Sheet Millman's Association); Mr. A. Pugh, Mr. J. Walker, Mr. W. T. Griffiths, Mr. T. Griffiths (Iron and Steel Trades Confederation); Mr. Owen Coyle (Amalgamated Society of Steel and Iron Workers of Great Britain); Councillor T. McKenna, Mr. H. Nixon, J.P., and Alderman P. Walls, J.P. (National Federation of Blast-Furnacemen). The Committee held their first meeting on the 5th inst. at the Employment Department, when Mr. T. W. Phillips, Acting Assistant Director of the Employment Department, welcomed them on behalf of the Minister. Mr. Arthur Pugh was elected Chairman, and Alderman Walls, vice-chairman. The Committee then considered, among other questions, the question of the opening of new Employment Exchanges and local offices in iron and steel working districts, and a proposal to the effect that in selecting applicants to fill a vacancy, Employment Exchange officers give the preference, other things being equal, to a man who had been discharged from His Majesty's Forces. The Committee expressed sympathy with the latter proposal, subject to standard conditions and wages in each industry being safeguarded, and referred it, as regards details, to their next meeting.

A meeting of the Sailors' and Firemen's Panel of the National Maritime Board under the presidency of Sir Leo Chiozza Money, M.P., was held on Monday, December 10. As a result the following scale of rates has been agreed for men of the Engine-room Departments:—Men Serving on Monthly Articles: Donkeyman, 13*l.* monthly; storekeeper, 13*l.* monthly; leading fireman (when carried), 12*l.* 10*s.* monthly; greaser, 12*l.* 10*s.* monthly; fireman, 12*l.* monthly; trimmer, of more than 1 month's sea service, 11*l.* 10*s.* monthly; of less than 1 month's sea service (this rate not to apply to any man who has already served or is serving as trimmer), 7*l.* 15*s.* monthly. Men serving on weekly articles, finding their own food: donkeyman, 4*l.* 2*s.* 6*d.* weekly; greaser, 4*l.* weekly; fireman, 3*l.* 17*s.* 6*d.* weekly. The rates named are inclusive of all bonuses and additions, and do not apply to vessels under 200 tons gross, or to vessels sailing under the share system. These and other exceptional cases, including railway-owned vessels, will be separately considered. In the meantime the officers and men of any department not included in the determinations now announced are reminded that they are fully protected as to the new rates about to be fixed, by virtue of the restrospective

clause in their articles, so that they suffer nothing by signing on at their existing rates.

Mr. W. A. Appleton, in an article in the December issue of *The Federationist*, relates his experience in the course of a recent visit to the Front. He states that "in the actual war zone every effort is made to minimise waste. Spent cartridges, broken clips, old horse shoes, even the nails that are scattered when a horse shoe is cast, are collected and brought down to the base. Mess tins, wagon wheels, dilapidated boots, discarded clothes and blankets, are all gathered up and transferred to a sorting, repairing and distributing centre. Thousands of articles, including boots, tents, blankets and guns are repaired and sent back for further use. Employment in these places is given to many thousands of people. The French girls are said to be admirable workers. Those I saw were working rapidly, and most of them were singing.

"The provisioning of an army such as this country has in France requires the highest organising skill and the utmost devotion to duty. One place alone turns out 300,000 loaves a day, and it was interesting to learn that the officer in charge, who is a colonial, had found from experience that he had reached his maximum production on an eight-hour day . . . . " Mr. Appleton then deals with the work of our soldiers; he contrasts their former home life with the life at the Front, and at this point concludes his article by stating that such a contrast formed the burden of the thoughts that were in his mind as he came down the lanes and roads from the battlefields. These were still the thoughts in my mind," he adds, "when I reached London and heard that 50,000 munition workers were on strike in Coventry. I could not help exclaiming, 'Good God, is there not common sense enough in Coventry to avoid a strike which adds to the dangers and the miseries of the men whom I have seen tramping into the darkness, and who are already enduring so much?' "

Dr. Ripper, the Vice-Chancellor of Sheffield University, in a paper which he read last week on "University Education in relation to Mining Engineering," urged that there should be built up in the centre of the local coalfield a department for training efficiently the best possible type of student to go out into the mining industry afterwards and be responsible for the introduction of every possible form of improved method. It was essential that a sufficient number of properly trained students should present themselves for the further training which the mining department of the University offered, and hitherto the supply of students of this type had been altogether inadequate. He stated that the Rothervale Colliery had arranged to select 12 boys annually and to give them a thorough training both practical and theoretical, the latter side of the instruction being received at the University.

He strongly urged that every industry should get the very best possible quality of boy at the start. For years past the young Germans had been having a splendid education in their great mining schools and had been sent out to the British Colonies and to neutral countries until Germany had more or less put her hands on the very fundamental industries on which our nation and Empire depended for their well-being. That had got to cease.

Mr. T. Brownlee, of the Amalgamated Society of Engineers, issued the following statement at the close of a meeting of representatives of engineering employers and employed which took place last Friday in London in regard to shop stewards:—

"After discussion, it was found that the question was one which offered favourable possibility of adjustment on a constitutional basis. The employers agreed to give the matter sympathetic consideration. The shop stewards, as thus proposed, would form a new link in the existing constitutional procedure, and, if recognised on a constitutional basis, would form a useful means for keeping the unions in touch with workshop conditions, as they vary from day to day. They would also offer an additional means of bringing the management into closer touch with the workpeople employed in the factories.

"Discussion was adjourned until Wednesday, December 12 No official statemert was issued after the meeting of Wednesday, but it is reported that the recognition of shop stewards was agreed upon, and that there only now remained to settle questions of detail.

The dispute which had arisen in the Midlands sheet metal industry is now settled. At the meetings which were held last week in Birmingham and Wolverhampton, the operatives were practically unanimous in their decision to resume work forthwith on hearing from their representatives the account of interviews with representatives of the Government.

We read in the *Yorkshire Post* that a conference between delegates representing the Associated Society of Blacksmiths and Ironworkers and the Amalgamated Society of Smiths and Strikers was held in Leeds last week. The Blacksmiths' Society has a membership of 16,500, and the Smiths and Strikers of 11,250. Both societies have taken a ballot vote on the question of amalgamation, and in each case, it was observed, by a majority of, roughly, 11 to one. The Blacksmiths' Society, of which Mr. John Thomson, of Glasgow, is the general secretary, has already taken in the London Hammermen, the Smiths and Hammermen, the Combined Smiths, the Co-operative Smiths, and the Dublin Smiths, along with the remainder of the old Smiths' Friendly Sick and Burial Society, which was established in 1834. The latest amalgamation, which the Leeds Conference has practically sealed, secures one society for all the smiths and strikers in the British Isles. The financial position is a good one, the Blacksmiths having a general fund of more than 43,000*l.*, and the Smiths and Strikers roughly 18,000*l.*, of which sum 12,000*l.*, is invested in War Loan Stock. One important arrangement ratified at Leeds will enable eligible members of the latter society to participate in the superannuation fund, which is an important feature of the Blacksmiths' Society.

The Ministry of Munitions and Admiralty announce that subject to any special demand which may be made upon individual firms by any Government Department in cases of extreme urgency, it is desired that Munitions establishments should take their customary Christmas or New Year holidays. If any question arises as to the duration of the holidays in any individual establishment, the firm concerned is requested to communicate with the Area Secretary of the Ministry of Munitions, or the Director of Munitions in Scotland, or, in the case of an Admiralty firm, with the District Director of Shipyard Labour. In view of the urgency of all war work, it is expected that all workers will return to their jobs punctually on the date fixed for the resumption of work after the holidays.

It is officially announced that in pursuance of the powers conferred upon them by the several Proclamations prohibiting the importation of certain articles into the United Kingdom, the Board of Trade will issue licences for the importation of machinery for agricultural and dairy purposes from the United States of America and Canada on the recommendation of the Agricultural Machinery Department of the Ministry of Munitions, 8, Northumberland-avenue, London, W.C. 2. Persons or firms desiring to import machinery and implements for these purposes must apply to the Agricultural Machinery Department of the Ministry of Munitions for the necessary permit to arrange for the import of such articles. Permits, when granted, will be forwarded to the Board of Trade, Department of Import Restrictions, 22, Carlisle-place, S.W. 1, for the issue of the necessary licences. Such imports will be carried at Government rates of sea freight, and their price to users must not exceed the total cost of the article landed in this country, plus 25 per cent. The foregoing provisions as to Government freight rates and control of prices do not apply to articles retailed at 40*s.* or under.

The National Service Department are seeking to obtain a large amount of unskilled labour for work in shipyards, and a strong appeal is made to men at present employed in unessential industries. Practically the only qualification for this work is normal physical strength. It is to be a condition that no man will be enrolled until there is a job for him—an important point compared with the original scheme. A man will not necessarily get the job he applies for, and he will not be actually enrolled until he is accepted by the employer. Among the men who are considered as doing unessential work are those employed as porters and warehousemen engaged in the packing and carriage of such things as women's clothing; men servants guarding the front doors of cinemas, shop assistants, and male lift attendants. An unessential job is described as one that a womarr could fill, provided that the man is fit for work in a shipyard.

The pay will be the rate of the present job, or that of the new job, whichever is the higher. The man employed will receive over and above his wages the following allowances:—

1. Travelling: (*a*) If the employment is at a distance beyond that which, in the opinion of the Minister, he can reasonably travel daily from his home, a free railway warrant at the commencement and completion of the employment; or (*b*) if within daily travelling distance from his home (exceeding half an hour each way), the cost of workman's tickets and one hour's travelling time per day at the rate of time-and-a-half; or (c) if within daily travelling distance from his home (not exceeding half an hour each way), the cost of workman's tickets only.

2. Subsistence.—If the employment is at a distance beyond that which, in the opinion of the Minister, he can reasonably travel daily from his home, a subsistence allowance, if necessary, whilst he is working in such employment at the following rates: If married or if unmarried and his home is mainly dependent on him, 2*s.* 6*d.* per day for seven days per week; if unmarried and his home is partially dependent upon him, 1*s.* 6*d.* per day for seven days per week if he shows to the satisfaction of the Minister that he has dependents for whose maintenance he is responsible and from whom he is obliged to be separated owing to his being in such employment.

3. Out-of-Work Allowances.—If, after being placed in employment by the Minister of National Service, his employment, owing to no fault of his own, comes to an end during the war and no further work is available for him, he may be entitled to receive whilst no work is available an out-of-work allowance at the rate of 3*s.* 6*d.* per day (including Sunday) for a period not exceeding four weeks, the first payment to be due one week after the commencement of his unemployment.

Communications may be addressed to Mr. F. J. G. Dimbleby, Publicity Department, Ministry of National Service, Hotel Windsor, Westminster, S.W.

The Prime Minister has appointed Mr. James Fullerton to be a member of the Committee on Production as an additional member in the place of Colonel J. M. Denny, C.B., who is temporarily unable to act on the committee owing to illness.

Professor A. W. Kirkaldy, Birmingham University speaking at a meeting of the Birmingham Rotary Club last Monday, said he had no doubt that the woman in industry had come to stay, and when the men understood what she did they would be quite willing for her to stay. In his opinion the war would not have ended long before there would be great commercial activity. Before the war we had a labour force of about 8,500,000 people, of whom about 25 per cent. were women. Considering deductions of men and additions of women we were about 750,000 short of the labour force we originally had. The country had been called upon to give an augmented output with 750,000 workers short of the numbers engaged before the war. And we had done it. He did not believe that the disbanding of our army would produce the dislocation so many feared. Of the 2,500,000 of men taken from industry, a considerable number had been either killed or permanently injured. Then a considerable number would never return to their old avocations; having tasted of the outdoor life, they would never settle down in small houses in crowded towns again. Probably they could account for 500,000 in that way. So that the number to return to our industries was not so formidable, after all. Then again, the army would not be disbanded suddenly. Even when peace came, 1,000,000 men would probably be kept under arms for a considerable time; they would be required to do what might be described as police work. The conviction he had was that it would not be trade that we should be short of after the war, but labour. He believed there would be more work than workers.

After the war we should be the best equipped nation in the world. We had crowded the country with the finest machinery the world could produce, and that ought to be a great asset to us. We had the best machinery, the best labour, and the best organisers, for he was perfectly certain that the British employer was the best organiser in the world. He had proved himself so during the war; and if labour and capital would only come together there might be an era of great prosperity before us. But there must be no suspicion. Labour must not be kept in the dark. Manufacturers must say to the recognised leaders of labour: Here is this great mass of trade waiting to be done. We can do it, and we can afford to pay good wages if you will give us the output. But there must be no secrecy; all must be fair and above-board. There must be no cutting of the rate because men happen to be earning considerably more than they earned before the war. They were entitled to earn more; it would be to the employers' advantage to pay them good wages. There would be only two European nations ready to cope with the world-demand that would arise after the war. In railway material and rolling stock, in shipping, in houses and house requisites, in every direction there would be a world demand, since stocks had vanished. We should have the chance of doing a huge trade; all that was needed was unity of effort, and a period of prosperity and happiness as a nation was before us.

THE LYSHOLM TRAVERSING PLATE PUNCH TABLE.

CONSTRUCTED BY THE NORBOM ENGINEERING COMPANY, ENGINEERS, PHILADELPHIA, PA., U.S.A.

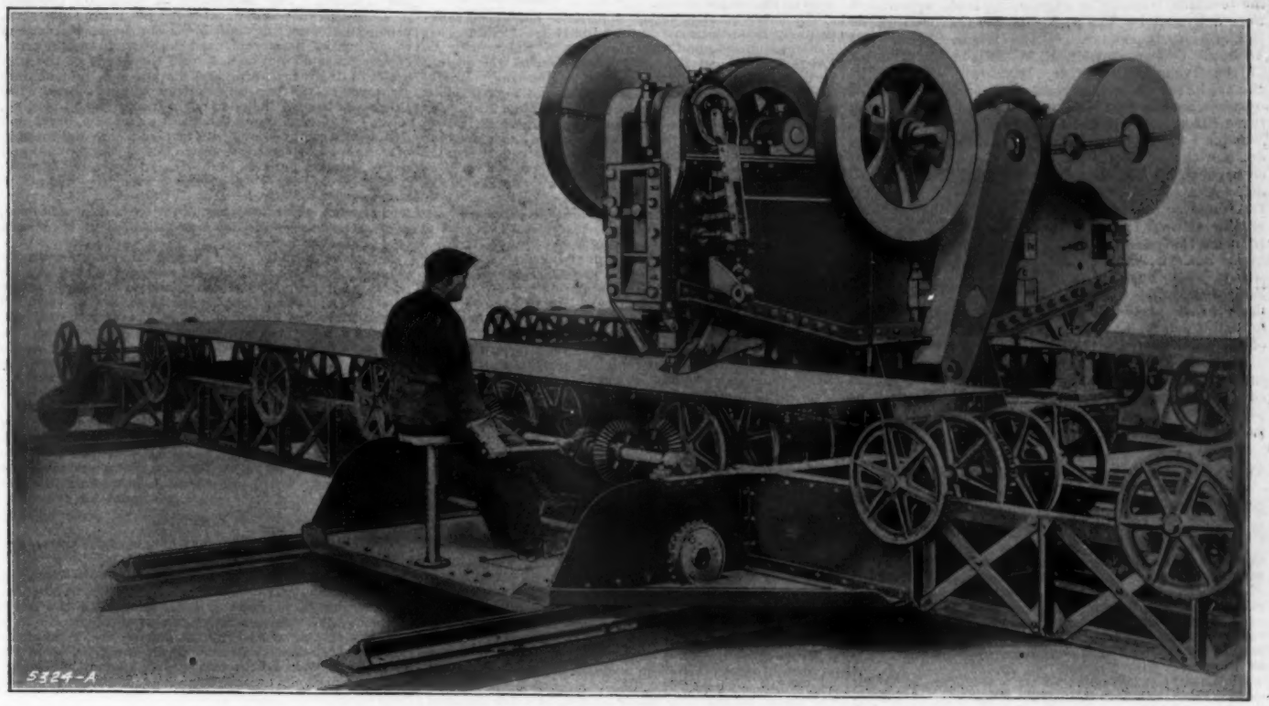

FIG. 1.

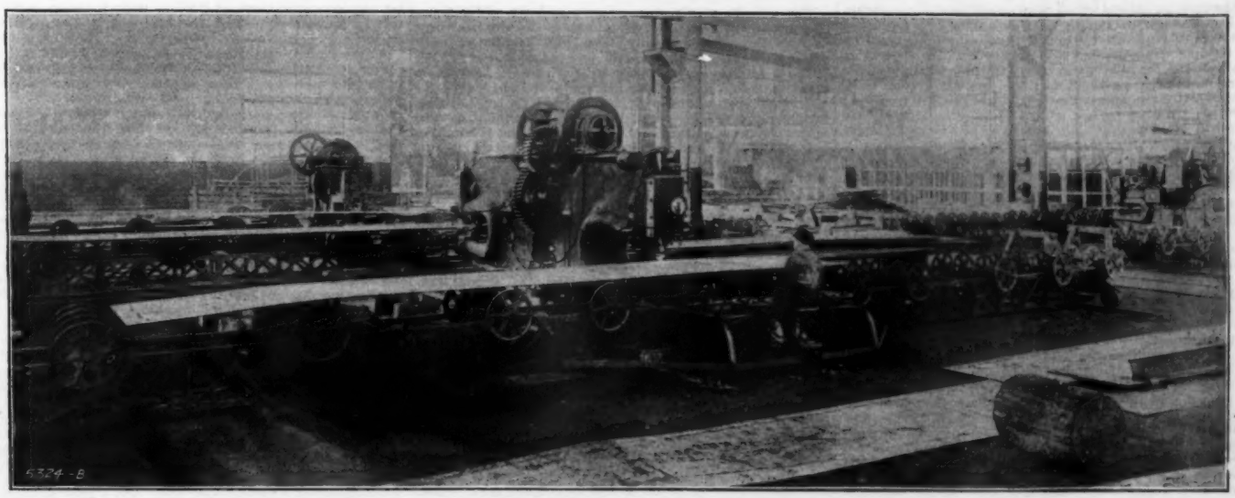

FIG. 2.

THE illustrations on this page show an adjustable table for facilitating the punching of ship plates. It will handle plates from ¾ in. to 1¼ in. thickness, and in sizes up to 30 ft. long by 8 ft. wide; a smaller machine will deal with plates up to 25 ft. in length. The average number of holes that can be punched in a nine-hours' working day is 4,000, but in some cases 6,700 holes have been punched in that time. The plate is laid on the table and the operator moves the table backward and forward by the operating lever on his right, and sideways by the lever on his left. When the plate is in the exact position the punch is tripped by means of a foot pedal. These tables are carried on roller bearings. They are, therefore, extremely light to handle, and one man can adjust them with the minimum of effort.

This machine has met with a ready reception among the shipbuilders of America. Fig. 1, showing one table, is from a photograph taken in the works of the Pennsylvania Shipbuilding Company, Gloucester, New Jersey, and Fig. 2 in the works of the Bethlehem Steel Company, Sparrow Point, Maryland. The Bethlehem Company have 14 tables; the Federal Shipbuilding Company, New York, 10 tables; the Sun Shipbuilding Company, Chester, Pa., 8 tables; and several other firms, 2, 3, 5 or 6 tables. The makers of the Lysholm traversing table are the Norbom Engineering Company, Philadelphia, Pa., U.S.A.

SELF-TIPPING LORRY FOR THE CITY ELECTRIC LIGHT COMPANY, BRISBANE—ERRATUM.—In our account of the self-tipping lorry, published in our issue of November 30, page 574, we stated that the motive power was derived from the Chloride Company's iron oxide battery. The Chloride Company now inform us that the definition should have been "Ironclad-Exide Accumulator."

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a new list (2041) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

MEXICAN PETROLEUM EXPORTS.—During June and July last, Mexico exported approximately 2,000,000 tons of petroleum, and it was estimated that the petroleum exports of that country for August and September were not far short of 3,000,000 tons. There would appear to be plenty of oil in Mexico, if transportation facilities were available, comments *The Motor*. The largest capacity well in the world is stated to have been brought into work there, with a potential output exceeding 150,000 barrels daily.

THE TRAINING OF ENGINEERING APPRENTICES.

Last summer there was held at Rochdale a conference of engineering teachers of Lancashire and Cheshire, and at this meeting addresses dealing with the technical training of engineering trade apprentices were delivered by Mr. A. E. Carter, the head of the Engineering Department of the Wigan Mining and Technical College, and Mr. R. W. Bailey, the principal of the Technical Institute, Hightown, Crewe. Mr. Bailey, in his address, advocated the establishment of separate courses for "engineering" and "engineering trade" instruction (termed by the Board of Education "major" and "minor" courses respectively), and dealt with the factors affecting the organisation of such courses. Mr. Carter, on the other hand, recommended a single course which makes provision for trade instruction, as the best solution of the problem, and he showed how such a course may be organised to meet the needs of apprentices of different attainments and capabilities. The delivery of the addresses was followed by a well-sustained discussion, and the conference expressed the opinion that the addresses deserved a much wider publicity, so that the views set forth in them might receive the attention and criticism of engineers generally.

In view of the very great importance at the present time of the subject dealt with, we now print both the addresses, in a slightly abridged form, and we shall be pleased to give space for their discussion in our columns. The addresses are as follow :—

The Need for Minor Courses of Instruction for Apprentice Fitters and Machinists and their Organisation.

By Mr. R. W. Bailey, Wh.Sch.

The present limited provision of Minor Engineering Courses* warrants the assumption that there is not enthusiastic unanimity regarding the need of this type of instruction, although there is certainly a widespread feeling that the existing major courses do not make suitable provision for the needs of engineering apprentices who are training to become craftsmen. I will, therefore, preface my description of our experience at Crewe of the working of a minor course for apprentice fitters and machinists by a statement of the circumstances which call for an extensive introduction of this kind of instructions, and refer to the broad principles which should underlie the organisation and running of these courses in conjunction with major courses.

The existing evening engineering instruction originated in the evening classes which were established a generation and more ago to supply the scientific and technical instruction required by young men who were training to become draughtsmen and engineers. At that time the facilities for full day technical training in engineering were practically nonexistent; and workshop conditions were such that an apprentice had a fair chance of receiving a broad training in his trade. To-day conditions are changed considerably. On one hand the more intimate application of science to industry, and the extensive introduction of day technical training in engineering has helped to raise the standard of evening instruction, and on the other hand the sub-division of labour and close specialisation in the workshop has in many cases greatly narrowed the outlook and experience of the apprentice. As a result of these developments the construction and standard of the present major courses can only be said to provide effectually for the few youths who are able to rise above the bench, and they leave the great bulk of apprentices, who are now in urgent need of technical instruction, comparatively unprovided for. An examination of the syllabuses of instruction, and an analysis of the numbers of students passing the several years of an evening engineering course, aided by an enquiry regarding their ultimate occupations, is sufficient to confirm at once the preceding statement. It will be agreed that the present major courses are needed for training the few who are fitted to receive benefit, and that every effort should be made to improve their efficiency; but as it is also essential that adequate provision should be made for training the trade apprentice the question arises whether the major course can be modified to meet the needs of the trade apprentice and at the same time preserve its value in training youths of greater ambition and abilities, or whether separate major and minor courses offer the best solution of the problem.

It is my opinion that where numbers are sufficient the establishment of separate courses is the best plan to adopt for the following reasons :—

1. The function of a major course is to provide for youths who are capable of rising above the bench, that is to say, for youths of more than average ambition and capacity. The degree of concentration required, therefore, is necessarily beyond the capacity of the average trade apprentice.

2. The time available in the evening is too short to permit the inclusion in the major course of organised trade instruction such as would suit the average apprentice, and the superior abilities of major course students must be relied upon to enable them to acquire a sound knowledge of workshop matters as a result of their own experience and observation in the works, guided wherever desirable by their teachers. In this way as much time as possible is made available for the acquisition of knowledge which can only be imparted at a technical school.

3. The average apprentice training to become a craftsman needs special instruction from a different point of view to that taken by the major course. The instruction should be very easily graded and the pace much slower than in the major course.

The needs of the average apprentice have been satisfactorily taken into account by the Board of Education "Memorandum upon the Teaching of Engineering in Evening Technical Schools" under Section III dealing with minor courses in mechanical engineering. Briefly it may be said that his knowledge of mathematics need not be extensive, but it ought to be sufficient for him to deal readily with the measuration of machine parts, speed and feed of machine tools, times and prices for different classes of work, and he should have an accurate knowledge of bonus systems. In the subject of engineering drawing it is not so important that he should be able to produce a good drawing as to read one with facility, and be able to make intelligible sketches from actual parts and from drawings. The point of view to be taken by the teacher is not that of design but production. In addition the apprentice should have a general knowledge of the production, characteristics and uses of engineering materials, and he should be given extensive instruction, aided by practical work, in the use of machine tools and appliances, the construction, erection and running of power plant, and in the most up-to-date workshop methods and processes. Also it is desirable that he should have a knowledge of mechanics and heat, largely qualitative, but sufficient to enable him to understand the processes and phenomena falling within his province. It is needless to add that the construction of any course, and its bias will depend on local conditions.

Passing now to the problems of the distribution of students upon the major and minor courses, the following plan will be found satisfactory.

Major Course.—Admission should be governed mainly by attainment, and the qualification needs to be set high enough to ensure the entry of only suitable students. It will happen that some students who wish to join the major course will fail to qualify. These would enter the minor course, and, if their progress is satisfactory, they would be allowed to take the major course a year later. It may be pointed out that these students would not mark time, as the first year of the minor course would constitute a sound introduction to the major course.

Minor Course.—This course would receive a small number of students having a desire to enter the major course, but not qualified to do so; a much larger number who desire to take the minor course, and are qualified for no other, and a few who, although qualified to enter the major course, prefer to follow the minor course. Care is needed in dealing with the latter and generally they may be dealt with as follows :—

The objects of the two courses and the obligations imposed would be fully explained to ensure that any preference is satisfactorily founded. Youths of only average promise would be given entire freedom of choice, without persuasion one way or the other. Youths of more than average promise whose age would allow them to obtain adequate benefit would have their attention focussed upon the greater opportunities offered by the major course, and they would be recommended to enter that course. In cases where the minor course is chosen, transfer to the major course would be permitted at a later date, as also it would be encouraged in the case of minor course students which give evidence of possessing marked ability.

It will be evident that where separate major and minor courses are established it is necessary to have two standards governing admission to the school. And in areas where evening continuation schools contribute to the supply of students to the technical school, two leaving standards are thereby imposed upon them.

An outline may now be given of our experience at Crewe of a minor course arranged mainly for appentice fitters, and reference made to the improvements we are introducing in the session 1917–18.

Four years ago it became evident that the policy of insisting upon students attending grouped courses of instruction in several subjects led to the entry into the engineering course of a considerable number of youths who had no enthusiasm for the course, but who were chiefly desirous of acquiring a knowledge of engineering drawing to aid them at their trade. In order, therefore, to relieve the engineering courses of unsuitable students, and also to provide better for the apprentice fitter it was decided to add to the then existing minor courses in boiler makers' work and metal plate work a minor course in fitting and machine work. We were then, and are still, without a workshop, but it was felt that in spite of this deficiency a course could be devised which would be much more suitable for the trade apprentice than the major course in engineering. This view has been confirmed by our experience.

The first-year course was common to all trades. It comprised instruction in mathematics, drawing and mechanics and heat (optional), similar in standard to the second year preliminary technical course of the Union of Lancashire and Cheshire Institutes, but it had a more practical bias. The second and third year courses required attendance on two evenings per week, the subjects of instruction being workshop processes (two hours) and engineering drawing (two and a half hours). The following optional subjects were introduced without extra fee, viz., practical mathematics (first year major engineering course) in the second year course, and this subject or mechanics and heat engines (first year major engineering course) in the third-year course. The intention of the optional subjects was to encourage the students to extend their study, and to provide a link facilitating transfer from the minor to the major course.

The instruction in engineering drawing in the second and third year courses was similar to that given in the first and second year major engineering courses, respectively, but the standard was lower, and the manner of treatment was adapted to suit the special needs of the students. The instruction in workshop processes in the second year course covered : engineering materials, production of castings and forgings; forms and uses of the principal hand tools and measuring instruments; transmission of motion; simple treatment of the processes of drilling, turning and shaping and the machines employed; and marking off in simple cases. The third-year course included :, the processes of planing, milling and grinding; the function of the parts and fittings of a steam engine, valve setting, care and running of steam plant; the construction and working of gas and petrol engines, ignition and wiring, and valve turning. A fourth-year course was projected which devoted attention to engine erection and repair; design of jigs; inspection of work, and rate-fixing, but it has not materialised, and as the courses are now recognised, there is no need to give further details.

Naturally we have been greatly handicapped by the absence of a workshop, but by making as much use as possible of the optical lantern and of our engineering laboratories, and by paying visits to works, succesful courses have been conducted. In the matter of works visits we have been specially fortunate in having the extensive locomotive works of the London and North-Western Railway Company close at hand, and we are much indebted to Mr. C. J. Bowen Cooke, M.Inst.C.E., chief mechanical engineer to the company, for the assistance he has always given to our efforts. Carefully conducted visits to the Crewe works have been made by the class, accompanied by its teacher (who is in the employ of the company) to such departments as the steel works, rolling mills, foundry, forge and machine shops, at times when the processes carried on in these departments have been under discussion at the class. Unfortunately it has been necessary to suspend works visits during the war.

Our experience of the foregoing minor course has yielded the following conclusions :—

1. Whilst a properly balanced course requires workshop instruction, much can be done in the absence of a workshop to provide a more suitable course for the trade apprentice than the average engineering course.

2. Where major and minor courses are conducted, it is necessary to have two standards of admission to the technical school, viz., a fairly high one for the major course, and one for the minor course low enough to admit the average trade apprentice.

3. The provision of a link between the major and minor courses in the shape of optional subjects has been found to be both unnecessary and unsatisfactory. In planning a minor course it is undesirable to be fettered by any considerations of linking with a major course, but to aim at providing the best course for training craftsmen.

4. Whatever mathematics is necessary for minor course students—and this is quite small—is best taught in an informal way in close association with the instruction in workshop processes.

5. In teaching engineering drawing, workshop needs should be kept prominently in view. Instruction in marking off may very well be associated with the drawing.

6. Our experience leads us to the view that a very satisfactory minor course can be arranged for apprentice fitters and turners extending over three years (exclusive of a preliminary course). Such a course would be of a general character, and it would require attendance upon three evenings per week, one of which would be spent in the workshop. This course might be followed by short courses in special subjects, *e.g.*, gauge and toolmaking; commercial testing of engines and boilers; internal combustion engines; workshop organisation. Also the first two years of the course might be framed in such a way as to serve as a general course for machinists; to be followed similarly by short courses in special subjects suitable for machinists.

In this way a whole group of courses for fitters and machinists would radiate from the central minor course.

In accord with the preceding conclusions the following alterations have been made in connection with our minor course for apprentice fitters and turners. The standard of admission to the major course has been raised slightly, thereby increasing the difference in the standards of the major and minor courses. The course now consists of a preliminary year, and a general three-year course in fitting and machine work. The conditions of admission allow the majority of students to enter the first year course direct, and it is expected that generally only a few backward students over 16 years of age will need to take the preliminary course. In each year, until a workshop is available, attendance is required on two evenings per week for the subjects of workshop processes and calculations (two hours) and drawing and marking off (two and a half hours). (It is hoped that later on the duration of this class may be reduced to two hours). When a workshop is provided an additional evening per week will be devoted to practical work therein.

The syllabus of instruction for workshop processes and calculations is somewhat similar for the first two years to that of the old course, but it provides for the necessary mathematics and it includes more experimental work. The third-year course in this subject covers : friction, work and power; transmission of power by belts, ropes and chains; power required for driving machine tools, measurement of the indicated horse-power and brake horse-power of steam and gas engines; and comprehensive treatment of the building and repair of locomotives.

* Courses of instruction for training engineers and craftsmen are now styled by the Board of Education major and minor courses, respectively.

During the first two years the instruction in the subject of drawing and marking off is arranged so that elementary machine drawing, reading of drawings and marking off is taught in close association. A considerable amount of marking off is done upon the desk top using suitable cast-iron model and machine parts.

A rectangular block of cast-iron, drilled in suitable places with ½ in. diameter holes ¼ in. deep to receive lead centres, lends itself for a variety of exercise work in marking off; and a wood scribing block mounted on three upholstery nails is quite satisfactory in use.

It is intended to devote the greater part of the third-year course to the following: design of jigs and fixtures; geometry of cams and of the single eccentric valve gear, practical treatment of valve setting for both single eccentric and reversing valve gears; detection of faults in valve setting, including the application of the engine indicator.

THE NEED FOR MAKING INSTRUCTION IN WORKSHOP PROCESSES A LEADING FEATURE OF PART-TIME MAJOR COURSES IN MECHANICAL ENGINEERING.

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I HEARTILY agree with Mr. Bailey in his conclusion that the present major part-time courses in most institutions are entirely unsuited to meet the needs of the average engineering apprentice who attends them. This does not refer to the whole-time day engineering student whose needs are quite different and call for different treatment.

I used to think that "minor" courses offered a suitable solution, and I still think so in the case of moulders, smiths, plumbers, boilermakers and (in a less degree) patternmakers. But for fitters, turners, machinists, &c., the following convinced me otherwise.

The fitting, turning and machinist trades are peculiar in that a certain amount of training in them is necessary for those who aspire afterwards to fill positions as draughtsmen, estimators, power-station engineers and managers with anything like reasonable confidence and success. Thus every lad who enters upon apprenticeship in these trades has before him the possibility of attaining to these higher technical positions provided he has native ability and can attain to the requisite educational standard. Thus in every group of apprentices there are some who will remain in the workshop, some will become draughtsmen, some estimators, some managers, other power-station or works engineers and a few may become engineering journalists or teachers or travellers or what-not. But which individual will ultimately fill any given position? There is no person who has the knowledge which will enable him to pick out with any certainty these individuals who will finally reach any one of the positions suggested above; if any person had such knowledge it might be possible to select the youths into groups according to their future sphere and to organise a suitable course of instruction for each group. But in the nature of things it is impossible to select the youths in this manner, and any attempt to do so would create future injustices and hardships.

If two parallel courses (major and minor) are to be adopted, we must have some method of selection.

1. Present educational attainment is not a suitable basis of selection. The mental powers of some young persons develop late, and their future attainment and status cannot be determined by their present mental development. Further, to select on that basis would stifle that determination and perseverance which is, in the long run, an excellent substitute for precocity and often yields even superior results than it does. Yet this is precisely the basis that is used for selecting students for minor as against major courses. I cannot regard this as a wise or even a fair arrangement.

2. The youths are not really competent to settle the matter for themselves. They have not that knowledge of the needs and the possibilities of their future that is necessary if a wise choice is to be made.

It seems to me that the only method that meets the necessities of the case, as also the only practicable course in the smaller centres, is to adopt a common course, comprising, in the earlier years, instruction suitable for all, and so framed as to permit of withdrawal at successive stages, the student having received instruction fitting him for progressively higher and wider careers as the course proceeds.

It thus becomes necessary to determine the elements common to the needs of all the careers that I have previously mentioned. These are undoubtedly (*a*) Power of calculation, (*b*) facility in reading drawings, (*c*) knowledge of workshop methods and of the scientific principles underlying the same. The sections (*a*) and (*b*) are necessary to all and (*c*) is necessary to all except perhaps some salesmen or travellers, but it is of importance to quite a large number even of these. A knowledge of workshop methods is certainly necessary to draughtsmen, estimators, managers, power-station engineers, works engineers, teachers and engineering journalists. The same wide applicability cannot be urged for a great deal of the present engineering science instruction using this term to indicate that portion of the curriculum which deals with mechanics, heat engines, hydraulics, &c. At present we single out a minority for special and exclusive consideration, namely, the designing staff, and the instruction we provide is quite unsuited for the majority who will remain attached to the workshop either as workmen, chargemen, foreman or managers. But we only partially meet the need of this minority, for we give them no instruction in the manufacture or production side without knowledge of which a draughtsman is bound to fall short of the highest efficiency.

I would therefore urge that instruction in workshop practice with the necessary underlying principles of physics and mechanics should take the place of the present instruction in engineering science at the beginning of the course, say the first three years. A student who completed this portion of the course, but went no further, would then have received instruction which would help him in a career in the workshop as workman, chargeman or foreman.

The instruction in the next two years should be such as would meet the needs of those who are destined to have charge of the operation of plant and those who have to be responsible for the safety of simple structures. This would include foremen and superintendents, power-station engineers, works engineers, colliery engineers and managers, &c. Such instruction would include mechanics, heat engines and other prime-movers, materials, transmissive machinery, &c., but on more practical lines than at present.

The last two years (making a seven years' course) would include instruction to meet the needs of those who desire to attain to the higher technical positions and would comprise higher work in mechanics, heat engines, materials and structures, hydraulics, aeronautics, engineering economics, law and organisation. This would be taught in a practical manner but much on the same lines as at present.

The following tabular statement will help the mind to grasp the general features of the proposed course. Syllabuses for the several subjects and stages will be given later.

Year of the Course.	Ordinary Courses. For those with Elementary School Education supplemented by Continuation School Preliminary Technical Courses 1 and 2.										Special Courses. For those who have attended a Secondary School to the age of 16 or thereabout.									
	Mechanical Engineering.					Electrical Engineering.					Mechanical Engineering.					Electrical Engineering.				
	Engineering Science.	Engineering Drawing.	Electrotechnics.	Mathematics.	Engin. Economics, Law and Organisation.	Engineering Science.	Engineering Drawing.	Electrotechnics.	Mathematics.	Electrical Design.	Engineering Science.	Engineering Drawing.	Electrotechnics.	Mathematics.	Engin. Economics, Law and Organisation.	Engineering Science.	Engineering Drawing.	Electrotechnics.	Mathematics.	Electrical Design.
1	1	1	—	1	—	—	1	1	1	—	1	1	—	3s	—	—	1	2	3s	—
2	2	2	—	2	—	—	2	2	2	—	2	2	—	4	—	—	2	3	4	—
3	3	—	1	3	—	A	—	3	3	—	3	—	2	5	—	A	—	4	5	—
A student ceasing to attend at this stage would have received instruction suited to the needs of a superior workman or foreman.																				
4	4	—	2	4	—	4	—	4	4	—	4	—	3	6	—	4	—	5	6	—
5	5	3E	3E	5E	1E	5	—	5E	5	1E	5	3E	4	—	1E	5	3E	—	—	{1 1E
A student ceasing to attend at this stage would have received instruction suited to the need of a foreman, superintendent, power station engineer, works engineer, &c.																				
6	{6A 6B	3E 4E	3E 4E	5E 6E	1E —	—	—	—	—	—	{6A 6B	3E 4E	—	—	1E	—	—	—	—	—
7	{7A 7B	3E 4E	3E 4E	6E	1E	—	—	—	—	—	{7A 7B	4E	—	—	1E	—	—	—	—	—

E = elective. In the sixth year of mechanical engineering, ordinary course.
Mathematics 5 must be taken if not taken in the fifth year.
Engineering Sciences takes two evenings in sixth and seventh years If number of students makes it desirable engineering science.
6 and 7 may be combined and the syllabuses taken alternate years.
6A, Heat engines. 6B, Materials and structures. 7A, Theory of machines. 7B, Hydraulics. All to pass degree standard.
Engineering Economics, Law and Organisation may be taken once in two years if numbers of students make it desirable.
Mathematics 3s. A special course for ex secondary-school pupils to prepare them for Grade 4.

I claim the following advantages of this proposed course over the major and minor course arrangement.

1. It will be noticed that an important feature of this proposal is the definite stages for withdrawal by those students who have reached the limit set by their natural capacity or their energy and determination or their ambition and desires. Nevertheless the curriculum and syllabuses are such that (*a*) those withdrawing at the end of the third and fifth years respectively will have received instruction definitely meeting the needs for progressively higher and more responsible positions. (*b*) Those remaining to later stages will have received instruction suitable to their needs so far as it has gone, the later stages supplementing this instruction in the same and other directions, the additional instruction being, generally, of a more advanced character suitable to their improved capacity.

2. Such a course would be self-selective as against the arbitrary selection of the major and minor courses, that is the teacher or principal is not placed in the thankless position of being required to single out certain students as fit only for the inferior or minor course. The student selects his own limits, but such selection takes place after three or five years' instruction, by which time the student is older and more experienced, and his outlook on life and on the engineering profession have developed somewhat, and he is able to appreciate the bearing of technical instruction on his work and on his prospects, and he is better able to gauge his capacity for the higher stages—as also is the person who is called upon to advise him.

On the other hand, at the end of a minor course, if the student recognises the need, and feels that he has the capacity, for the wide training he will be faced with the necessity of going back almost to the beginning of the major course, having lost two to four of the most useful years of that period of his life which he is free to give to study. This seems to me a very cruel dilemma in which to place a lad, and is a most damning objection to the minor course scheme; I deny that it is a merely theoretical objection; there are certain lads who develop late and who are just the sort to be forced into the minor course to find at the end that they have been grievously ill-advised.

3. At present much of the difficulty the student finds in the Engineering instruction arises from his inadequate mathematical preparation. The mathematical demands made by his engineering science studies tread insistently upon the heels of his mathematics instruction, before it has become well digested knowledge and assured skill. In the course proposed, the engineering science of the first three years will be chiefly descriptive, and will make comparatively slight demands on the mathematical knowledge and skill of the students. His instruction in mathematics is, however, going on all the time; consequently his mathematics will be in advance of, rather than in arrears of, his needs when he comes to the fourth and subsequent years.

4. The suggested order of treatment coincides in general with the order of a youth's progress at the works, and so enables us to utilise that important ally of the teacher—interest.

5. The period of the instruction in workshop practice, coinciding with the period of the student's service in the workshop, would make for improvement in the doing of his work there, and would create a further interest in that work. In a shop with enlightened management this would make for the student's advancement and would further impress him with the value of the technical school instruction. This would also go far to ameliorate, if not remove, the present hostility evidenced by many foremen toward the technical school.

6. This improvement of a lad's value in the workshop would, in many cases, mark him out for the privilege of experience in other branches of the firm's work, such as the drawing-office, test-department, plant-department, outside erecting, &c., which would widen the lad's experience and outlook, greatly accelerate his progress in his profession and probably create opportunities which otherwise would never have been his.

7. In any case he has learned early in his career to do his present work well and scientifically, of which the influence for good upon the lad's character cannot be over-estimated. The major course students would be debarred from this in the supposed interest of their preparation for higher positions which they may never reach for lack of doing their present work well.

Mr. Bailey's claims in favour of the major and minor course arrangement appear to be chiefly two:—

1. That the superior student in the major course can keep up a quicker pace than can his less able *confrere* in the minor course. While, of course, this is true, it must be remembered that where there are sufficient students to form major and minor courses there will be sufficient to form two sections of the general course. The members of these sections can be selected by suitable examination, checked by interview and by subsequent class experience, and the pace of the sections set to suit the respective average capacities.

2. That it is a pity to spend on a study of workshop practice time that might have been devoted to technical study, since workshop practice may be learned in the shop itself. There I entirely disagree. I think the experience of most engineers will coincide with mine, that little or no instruction is given to apprentices in very many workshops. (See a similar statement by Professor Ripper quoted on page 6 of a "Report on Mining Education in England with special reference to Index. 1916.")

I may add these further considerations:—

(a) Observation is a matter of training and is specialised and selective. I agree that what a youth gains by observation in the works will be increased by training his mind on broad lines, but it will be increased and enriched in a vastly greater degree by systematic instruction in workshop matters.

(b) A youth's experience in the workshop is limited by the work done, the character (progressive or otherwise) of the management, the character of the machines and other equipment, the interest taken by the foremen in the lads, the ability and experience of the foremen and a thousand other circumstances.

(c) Workshop methods have undergone, and are destined to undergo in the near future, immense developments which call for just as careful and thorough study as has, in the past, been given to technical mechanics and heat-engines. The problems of workshop processes, equipment and management have been too much neglected by us in the past; the time has come for us to revise our estimate of values and to give to workshop instruction its rightful place at the very base of an engineer's education.

In conclusion, I should like to urge the following additional considerations:—

1. The higher technical worker should not be a man with a knowledge running on different lines from that of his humbler colleague (as Mr. Bailey seems to suggest), but one whose knowledge is equal to that of the shop-worker and which has added to it the wider and fuller knowledge required for his work. The other notion appears to have held the field in the past and leads to the well-known scorn of the "practical man" for the "theoretical man." This is quite natural, for the theoretical man has been quite content to be a sheer ignoramus in regard to practical matters and the practical man has found him out as such, but has not been able to appreciate the importance of his theoretical knowledge because it is a matter beyond the practical man's ken.

A better breed of men for the responsible positions is a prime necessity of the engineering industry in this country at the present time, men with a wider outlook and knowledge of all branches. It also needs foremen and workmen better instructed in the developments and possibilities of workshop practice. Both of these classes my proposed course is designed to aid in producing.

2. I claim that by starting with that instruction which the students appreciate and value, we shall lead them on to the pursuit of further knowledge such as their developing intelligence, wider knowledge and unfolding experience shall tell them is necessary. The effect will be to induce a much larger number than at present to go on to the higher stages.

3. It has been suggested that compulsory continuation classes will solve our attendance problem without the necessity of making our courses more attractive. To me the moral seems quite the reverse; if youths are compelled to attend it is surely our duty to make our teaching of the greatest possible attractiveness and mental profit. Compulsion will be for only a few years of each youth's career; we ought, during the period of compulsion, so to meet the youth's felt need that he will be attracted to continue study after the compulsory period ends. Only so shall compulsion have its highest value.

I am aware that the scheme may be capable of improvement in detail, and would welcome criticism with that end in view.

SYLLABUSES.

The numbers indicate the suggested order of lessons—given chiefly to indicate the amount of work apportioned to one lesson. In engineering science this should occupy ½ hour to 1 hour each evening, the remainder being given to laboratory work. The numbers in the list of laboratory work indicate the lesson after which the students would be prepared to do the several items.

Engineering Science. Grade 1.

Workshop Processes.—1. Measuring instruments, fixed and limit gauges, scribing block and surface gauge, test gauge. 2. Kinds of fit and allowances.

Mechanics and Heat.—3, 4. Relationship between load and elastic deflection. 5, 6. The lever, moments, equilibrium of parallel forces. 7, 8. Polygon of forces and the two conditions of equilibrium. 8. Effect of heat on bodies, expansion, &c. 10, 11. Temperature, thermometers and scales. Coefficient of expansion. 12. Conduction of heat.

Workshop Processes (continued).—13. Cutting tools; how tool acts in cutting, rake, clearance and tool angles; best values. Lathe, &c., tools. 14. Chisel angles, forces on chisels. 15. Files, kinds, cuts, care and use. 16. Scrapers, straight-edge and surface plate, how to originate. Scraping and testing a surface. 17. Taper-turning, methods of desining tapers, guiding the tool, necessity that point shall move in plane containing axis of revolution. 18. Tool steel, composition and properties. Annealing, hardening, tempering, with underlying reasons. High-speed steels. 21 to 24. Speed, calculation of. Speed ratio of trains of wheels, rope and belt drives. Slip of belts. The revolution counter and its use. Gears for screw-cutting. Avoidance of interference of studs. Setting the tool for screw-cutting. 25. Marking-off. 26. Materials, general properties, weight, composition, cutting and wearing characteristics. Cast-steel tool steel, high-speed tool steel, mild steel, wrought-iron, cast-iron, brass, bronzes, phosphor-bronze, aluminium. 19, 20. Forging and smith's work. The forge and its equipment. Construction of hearth. Smith's tools. Welding, flux, welding-temperature jumping, swages and blocks.

Laboratory Work.—1. Gauging with fixed and limit gauges. 2, 3. Experiments on elastic deflection. 5. Levers, movements. 7. Polygon of forces. 9. Effects of heat. 10. Reading temperatures, coefficient of expansion. 12. Conduction of heat. 13. Plain parallel turning, using (1) calipers with plug gauge, (2) limit gauges. 14. Setting small surface plate to line and machining to line in shaping machine. 16. Students working in sets of three to originate straight edges and surface plates. 17. Taper-turning. 19. Simple forging. 20. Simple weld. 21. Slip of belts. 24. Screw-cutting. 25. Marking-off from sketch.

Engineering Science. Grade 2.

Workshop Practice.—1, 2, 3. Theory of cutting tools applied to drills, twist drills, clearance and backing-off. Thinning of point, purpose and method, grinding twist drills. Milling cutters, various forms, grinding. Taps and dies, backing-off, grinding. 4. Milling machines, classification and details. Milling screw threads, advantages and methods. 5. Grinding wheels; grade, grit bond, suitability for different purposes and considerations governing choice. Grinding machines and operations. 6. Broaching, construction of a broach. 7. Tempering of delicate and sharp-edged work. Tempering in oil and alloys. 8 to 12. Manufacture of cast-iron, wrought-iron, mild steel, copper, aluminium. Alloying. 13. Soldering and brazing. Composition of solders and brazing metals. 14. Case-hardening various methods, and their respective advantages. Prevention of distortion.

Strength of Materials.—15. Stress. Strength and necessary size of tension and compression members. 16. Commercial tension test. Limit of elasticity. Yield load, maximum load, ultimate load and corresponding stresses. 17. Strain, modulus of elasticity. Expansion due to heat and stresses caused.

Workshop Practice (continued).—18 to 20. Repetition work, principles of and design of jigs and fitments. 21, 22. Moulding and pattern-making, greensand moulding, simple typical cases. 23, 24. Loam moulding, strickling boards, pipe moulding, cylinder moulding. 25. Marking-off, more difficult. 26. Autogenous welding, general principles and methods of oxy-acetylene, electric-arc and other methods. 27. Lacquering and enamelling, cold-lacquers, hot-lacquers and enamels.

Laboratory Work.—Work listed in Grade 1, not yet done, together with 6. Broaching holes of various shapes. 7. Tempering simple object in oil or alloy. 13. Soldering and brazing. 14. Case-hardening a piece of mild steel. 16. Commercial tension-test and report. 21 to 24. Preparation of simple green-sand or loam mould. 25. Marking-off forging or casting from drawing or sketch. 27. Lacquering and enamelling metal.

Engineering Science. Grade 3.

Workshop Practice.—1, 2. Testing lathes for accuracy; bed-levelling, parallelism of longitudinal slide. Accuracy of head-stock, spindles and spindle-sockets, slide rest. Tests of finished lathes. Slide screw and leading screw tests. Turret-lathe tests. 3, 4. Testing for accuracy milling and drilling machines, planing and grinding machines. *Mechanics.*—5. Friction. Relationship of resistance to normal thrust. Coefficient of friction. 6. Work and its measurement, the work diagram. 7. Power, its measurement and transmission, the brake; electrical power. 8. Transmission dynamometers, their usefulness; the different kinds, especially those adaptable for workshop purposes. 9. Cutting-force tests on lathes, drilling, planing, shaping, milling machines. Tool dynamometers. 10. Speed and feed tests. Machine-tool efficiency. Output determination for various machine tools. 11. Comparative tool testing, the several methods and results.

Machine-tool Mechanisms.—12. Quick-return motions. 13. Epicyclic trains and differential gears; how to calculate velocity ratios. 14. Four-bar mechanisms, the toggle joint.

Workshop Practice (continued).—15. Gauge-making; the special problems involved. Lapping to size. Construction of laps and methods of use. 16 to 19. Special lathe appliances. 16. Mandrels: standard, collar, expanding, cone, screw. 17. Boring bars and cutters. Tool for recessing to predetermined size some distance in bore. 18. Tool-holders for high-speed steel tools. 19. Turning form-work. Copying principle form plates, non-circular work and former. Spherical and parti-spherical work. 20. Screw gauges. Methods of gauging screws. Special precautions necessary.

Heat.—21. Quantity of heat. British thermal units. 22, 23. Specific heat, heat of mixtures. 24. Sensible heat and latent heat of water and steam. 25. Total heat of steam. 26. Wetness of steam, dryness fraction. 27. Brief general description of working of steam plant.

Laboratory.—1 to 4. Accuracy tests on workshop machines. 5. Determination of relation of frictional resistance to load. 7. Measurement of brake power. 8. Measurement of power by means of transmission dynamometers. Relationship of slip of belt to power transmitted and to breadth of belt. 9. Cutting-force tests on workshop machines. 10. Speed and feed tests. 11. Comparative tool tests. 15. Lapping a piece of work to size. 22 and 23. Heat of mixtures. 24. Latent heats of water and dry steam. 26. Dryness-fraction by barrel calorimeter.

Engineering Science. Grade 4.

Steam Engine.—1. The steam boiler, general brief description of leading types, tank and water tube. 2. Measurement of cylinder power. The indicator and indicator gear; precautions necessary in taking diagram. Determination of indicated horse-power from diagrams. 3. Brakes, transmission dynamometers, measurement of shaft-power. 4. Measurement of flow of water by means of notches, weirs and orifices. 5. Engine testing, mechanical efficiency, steam and fuel consumption per horse-power-hour. 6. The simple slide valve and eccentric gear. Position of crank at events. Simple problems given travel of valve. 7. Transmission of power by belts and ropes, relation of tension. Strength of belts and ropes.

Materials.—8. Commercial tensile test in testing machine. 9, 10. Beams, bending moment and shear force diagrams. 11, 12. Tensile and compressive stresses in, and moment of resistance. 13, 14. Deflection of cantilevers, supported beams and beams built-in at both ends. 15. Columns and struts, relationship of collapsing load to length, cross-section and fixing. 16. Timbers, their properties as beams and struts for strength deflection and reliability. 17. Ferro-concrete, general principles of design of ferro-concrete beams and struts. 18. Shafts, stresses in and strength of power transmitted by shaft.

Kinematics and Dynamics.—19. Displacement, vel., accel.; relationships by means of vel.-time graph. 20. Effect of force in producing acceleration. 21. Impulse and momentum. Kinetic energy. 22. Resolution and composition of vel. and accel. Radial accel. of body moving in circular path. 23. Centrifugal force, simple balancing.

The Steam Turbine.—24. Principles of action, and description of most important types.

Internal-Combustion Engine.—25. Four-stroke and two-stroke cycles. Oil and petrol engines. The carburettor. 26. Diesel and semi-Diesel engines. Producer-gas and producers. Coke-oven and blast-furnace gases as fuel for engines.

27. *Compressed-air Plant.*—Description and efficiencies.

Laboratory Work.—2. Taking indiactor diagrams and determining indicated horse-power. 3. Determination of brake horse-power and shaft horse-power. 4. Determination of flow through orifices and over weirs and notches. 5. Simple engine tests. 6. Experiments on valve-gear models. 7. Coefficient of friction of belts and ropes on pulleys. 8. Commercial tensile test in testing machine. 13. Value of E for material by bending. 14. Experiments on struts. 16. Experiments on beams and struts of various materials to determine characteristics. 17. Testing ferro-concrete beams and struts. 18. Torsion tests in torsion machine. 20. Experiments on Atwood's machine. 23. Experiments on C.F. machine. 25. Taking indicator diagrams from gas, oil, petrol, &c., engines. 27. And from compressor.

Engineering Science. Grade 5.

The Production of Steam.—1. The steam boiler; measurement of economy. Calorific value of fuel, determination by calorimeter. 2. Testing coal for moisture, ash, sulphur. 3. Chimney draught; cause. Forced and induced draught. The manometer. 4. Points on raising steam, care of boilers, stoking and avoidance of smoke. Mechanical stokers. 5. Corrosion of boilers, water softening, filtration of feed water, evaporation. 6. Completeness of combustion. Flue-gas analysis, CO_2 recorders. 7. Feed pumps and injectors—relative merits. Feed heating and its advantages. Feed heaters and economisers.

The Steam Engine.—8. Properties of steam, latent heat, total heat. Superheated steam, dryness fraction. 9. Action of cylinder walls, importance of dry steam; barrel, separating and throttle calorimeters. Separators and steam traps. 10. Superheated steam and superheaters. 11. Effect of clearance, jacketing and compounding on efficiency; measurement of clearance volume. 12. More advanced problems on valve diagrams. Setting the valve. Piston, trick, double-ported and balanced slide valves. 13. Checking valve settings by indicator diagrams. Points on starting and running steam plant. 14. Hypothetical indicator diagrams. Theoretical mean effective pressure $\left\{ = P\left(\frac{1-\log_e r}{r}\right) - p \right\}$ Diagram factor. Dimensions of cylinder to develop given power. 15. Special problems connected with high-speed engine. Willan's central valve engine. Indicator rig for high-speed engine. Indicator for same 16, 17. Crank effort and torque diagram corrected for inertia. Flywheel, dimensions for given fluctuation of torque and speed. 18, 19. The centrifugal governor, its action, height, Crossed-arm governors. Isochronism, hunting, effect of friction, shaft governors. 20, 21. Valve gears. Description of link motions, radial and trip-valve gears.

Materials.—22. The load-extension diagram of a steel, wrought-iron and cast-iron test-piece. 23. Effect of sudden, repeated and alternating loads.

The Steam Turbine.—24, 25. Details of various types. Importance of high vacuum and how created. Compounding. Recent developments.

Internal-combustion Engine.—26, 27. Economy, how secured, dependence on compression. Calorific value of gas and oil fuels. The gas producer, points on running and maintenance. The Humphrey internal-combustion water pump.

Compressed-air Plant.—Efficiency, how secured. Details of compressors.

Laboratory Work.—1. Calorific value of coal by calorimeter. 2. Testing coal for moisture, ash and sulphur. 3. Reading chimney and smoke-box pressures. 6. Flue-gas analysis. 8. Relation of t and p of steam. Latent heat of steam. 9. Dryness of steam by barrel, separating and throttling calorimeters. 11. Measuring clearance volume of an engine. 12. Experiments on valve-gear models. 13. Checking valve setting from given indicator diagram. 16. Flywheel, radius of gyration, energy. 18. Experiments on governor model. 22. Load-extension test with autographic record. 23. Stress caused by suddenly-applied load, by spring balance. 26. Calorific value of gas and oil fuels. 28. Taking indicator diagrams from cylinder, receiver, &c., of compressor, and comparing with each other and ideal.

Engineering Science. Grades 6 to 9.

These grades deal with the more advanced engineering instruction to about Pass Degree standard of the London University, with appropriate laboratory work. If the number of students makes it desirable, two grades can be taken one year and the other two the next, and so on alternately.

Grade 6. Heat engines. Grade 7. Materials and structures.

Grade 8. Theory of machine. Grade 9. Hydraulics and aeronautics.

Engineering Science. Grade A.

The mechanics and heat done in Grades 1, 2, 3, to prepare mining and electrical engineering students (who do not take Grades 1, 2, 3) for Grade 4.

Engineering Drawing.

Grades 1 and 2.—Drawing from models and sketches. Instruction on elements and details of engineering construction.

Grade 3.—Simple rational design of transmissive elements of machinery, spur, bevel, worm, &c., gearing.

Grade 4.—Each student works individually on the design of a larger piece of work, chosen in consultation with the teacher, the design being worked out under the teacher's guidance and supervision.

Electrotechnics.

Grade 1.—Introductory magnetism and electricity, chiefly qualitative.

Grade 2.—Electrical measurements. Generation and distribution of continuous current for light and power purposes.

Grade 3.—Alternating current, generation and distribution.

Grade 4.—Grades 2 and 3 carried to a more advanced stage.

Grade 5.—Problems connected with the design, installation and running of electrical plants. Wireless telegraphy, cables, &c.

Mathematics.

Grades 1, 2, and 3.—Algebra, trigonometry, mensuration, graphs.

Grade 3a.—Special grade for ex-Secondary-School pupils, to fill up gaps in previous instruction and prepare for Grade 4.

Grades 4, 5 and 6.—Calculus, integral and differential. Series, harmonics. Co-ordinate geometry. Differential equations, &c.

Engineering, Economics, Law and Organisation.

Economics.—1 to 7. Man in his social and industrial relations; his consumption of goods. Conditions and factors in the supply of goods; natural agents, laws of increasing and diminishing return. Labour, its supply and efficiency, division of labour. Capital, its nature, form and functions. Some important aspects of production—organisation, direction and mobility of labour and capital, large and small production, machinery, localisation of industries. Nature and economic aspects of rent, wages, interest and profits. Prices. Trades unions—their history and economic and social functions. Industrial and capitalistic combinations. Conflict of Labour and Capital, arbitration, conciliation, mediation. Functions of Government. State regulation of industry. State and municipal trading. Taxation.

Law.—8. The law of contract. 9. Company law. 10. The Factory Acts and their administration. 11. The Workmen's Compensation and National Insurance Acts and their administration. 12, 13. The trades unions, law as applied to, current spirit and operation of trades unions and effect on workshop management.

Organisation.—14. Systems of workshop payment; time, piece and bonus systems. 15. Methods of time-keeping and cost-accounting. 16 to 18. Estimating the labour and materials cost of a piece of work and establishment charges to be made thereon. 19, 20. Drawing-office organisation. Systems of numbering product-parts. Standardisation of drawings; filing methods, record of changes; indicating quality of finish, limits of accuracy, &c., Checking drawings. Shop copies, production and mounting. 21 to 24. Workshop equipment; selection and purchase, installation, repair, numbering, indexing, locating and arranging, standardisation. Power required for machine tools. Tool-room methods. 25 to 28. Workshop organisation. Shop and production orders, stock and store methods, stock-taking. Inspection and checking of products. Inspection of materials, routing, following-up, despatching, inspection and operation cards. Committee work, suggestions—systems. 29, 30. Prevention of accidents, fire, sickness.

Practical Work.—Abstracting and re-compiling statistical

information from reports, &c. Making summaries of statutes and subsequent important judgments bearing thereon. Preparation of cost account of a manufactured product from a mass of workshop and time-office documents, store-sheets, &c. Preparation of estimate of material, labour and establishment costs for the manufacture of a piece specified by sketch. Preparation of stock sheets, store-issuing orders, shop and production orders, inspection sheets, instruction and operation cards, routing schedules, and other management schedules and forms.

DEALINGS IN PIG IRON.

WITH reference to the Order made by the Minister of Munitions on the 7th July, 1916, applying Regulation 30A of the Defence of the Realm Regulations to war material, consisting of certain classes and descriptions of metallurgical coke, pig iron and steel, and to the General Permit for dealing in such war material issued by the Minister of Munitions, on the 1st November, 1916, the Minister of Munitions gives notice that the said General Permit is modified by the insertion in the schedule thereto of the following, the prices for the articles hereunder specified being in addition to or, where such articles are already specified in such schedule, in substitution for the prices contained in such schedule.

Maximum Prices for Pig Iron above referred to—Hematite Pig Iron—East Coast and West Coast.

The expression "Mixed Numbers," where used in relation to East Coast and West Coast pig iron in the schedule to the said General Permit, shall mean equal quantities of Nos. 1, 2 and 3, having an average analysis within the following limits :—

	East Coast. Per cent.	West Coast. Per cent.
Silicon	1¾ to 3¼	1¾ to 3¼
Manganese, not exceeding	1¾	1¾
Sulphur, not exceeding ...	0.06	0.05
Phosphorus, not exceeding	0.06	0.05

The following extras may be charged on sales of East Coast and West Coast Hematite Pig Iron :—

	Per ton. s. d.
All Hematite Pig Iron selected to any particular number, grade or analysis, or manufactured to a specified analysis within the limits covered by mixed numbers	2 6
All Hematite Pig Iron selected or manufactured to a specified analysis outside the limits covered by mixed numbers, with a Silicon content below 5 per cent.	5 0
Silicon 5 per cent. and less than 6 per cent.	10 0
Silicon 6 per cent. and less than 7 per cent.	15 0

All the above additions to the schedule of the General Permit shall take effect from the date of this notice (December 5) and none of such additions shall be deemed to prejudice or interfere with the carrying out of any contract, in writing, for sale or purchase of the above-mentioned war material, entered into prior to such date at prices lawful at the date of such contract.

	Substituted Prices. Per ton net f.o.t. Makers' Works. £ s. d.
Cleveland Pig Iron—Foundry and Forge :	
No. 1...	4 19 0
Other Grades...	4 15 0
Cleveland Pig Iron :—	
Basic	5 0 0

The above-substituted prices shall take effect from September 17, 1917.

	£ s. d.
Lincolnshire Pig Iron :	
Basic or foundry	4 17 6

The above substituted price shall take effect from November 1, 1917.

THE SUB-PRODUCTS OF GAS MANUFACTURE.—Dealing with the sub-products of gas manufacture, Mr. Harry Jones, the new president of the Institution of Civil Engineers, stated in his presidential address to that Institution, delivered on the 6th ult., that there were ten products which, by their energetic combustion, were capable of explosion for war or motor fuel; there were 19 various colour dyes of great brilliancy; 9 drugs and antiseptics, among which saccharine and aspirin; 8 perfumes and flavourings; 10 salts of ammonia and cyanogen; and 1 sulphur for acid-making and fixing ammonia and cyanogen; altogether 57, and these might be brought out by further permutations into an almost endless number of interesting and probably, in the future, most valuable products. For war purposes, the first 10 and the last 11 products were especially useful.

THE ITALIAN MOTOR CAR INDUSTRY.—Italy, in striking contrast to other European nations, has enormously increased her exports of motor lorries and cars during the last three years. This is shown by statistics issued by the Italian Ministry of Finance for the first five months of 1917 (ended May 31), compared with the corresponding months of 1915 and 1916. During the first five months of 1915, Italy exported 2,541 motor vehicles of all kinds. For the corresponding period of the present year the figures have been increased to 3,647 automobiles. Obviously such a development has not taken place without a corresponding increase in the size of the Italian motor factories, and this is all the more wonderful when it is remembered that Italy is dependent on foreign countries for a large proportion of her raw material.

THE ACTION OF CAUSTIC LIQUORS ON STEEL PLATES.

WE reproduce from a memorandum just issued by Mr. C. E. Stromeyer, the chief engineer of the Manchester Steam Users' Association, the following interesting notes on the action of caustic soda on steel plates :—

In consequence of the revival of the colour industry the question of strengths of autoclaves and the influence of caustic liquors on steel has again had to be dealt with. The latter question seems to have been taken up by Professor Heyn, in Berlin, and by Professor Parr, in Illinois, but it appears that neither professor has been able to reproduce my early results. These had not been published because it was intended to deal with the question more exhaustively, and if possible to devise a reliable test for brittleness due to caustic soda, and to determine whether there is any difference of behaviour for different qualities of steel and iron, for varying stresses, strengths of liquor, and periods of exposure.

Our recent experience of the action of caustic soda was with some evaporator tubes. These cracked above and below the tube plate. At the plate zone, where the expander had produced a compression stress in the tube, there were no cracks; but tube plates, in which there would be tension stresses, and also occasional rivets, were very seriously affected. In order to ascertain whether, as suspected, the embrittlement of steel in contact with caustic liquor occurs only when the steel is in tension, the following experiment was carried out.

Several pairs of rings, as shown in Fig. 1, were cut out of a solid plate. Some of these rings had taper inner edges, others had taper outer edges. They were placed one above the other, as shown in Fig. 1, and the one ring was driven over the other as shown in Fig. 2. By this means the outer ring would be maintained in a condition of tension, and the inner one in compression. There were altogether seven rings. One ring was not stressed, but boiled for a short time, one pair was annealed before stressing, the other two pairs were not annealed. The one annealed, the other unannealed, but stressed rings were placed in a caustic evaporator in which the density was not excessively high, and these were returned to this office after four months' exposure. All the rings were then cut up into small segments, and of each ring one short piece was bent inwards, and the other outwards. The results were very consistent. All the untreated samples, and also all those which were in a compressed condition when exposed to the caustic bent double without the least sign of cracking; but the two, the annealed and unannealed, rings which were in tension while exposed to the caustic, cracked in innumerable places when bent. These cracks appeared both on the outer surface, which was in direct contact with the caustic, and on the inner surface which was not in contact with caustic but was pressing hard against the compressed inner ring. Evidently, therefore, the influence of the caustic had penetrated through ¼ in. of metal.

Fig. 1.

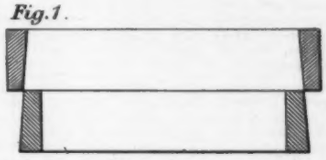


Fig. 2.

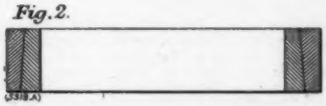


Fig. 3.

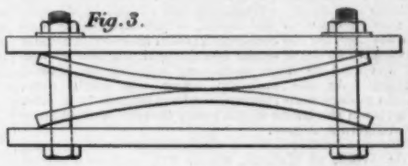
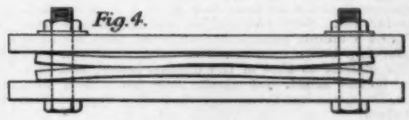


Fig. 4.



In view of repeated inquiries, and also because of a very alarming experience, it was decided to deal with the question on more comprehensive lines. Accordingly four sets of bars were obtained, viz., open-hearth steel both acid and basic, Bessemer steel and wrought iron. They were cut into 10-in. lengths, curved in boiler rollers, placed back to back between two stout iron plates (see Fig. 3), and the end screws were then screwed down, whereby the samples were nearly flattened as shown in Fig. 4. In the meantime four autoclaves were produced, one set of four samples was inserted in each one of these, caustic soda solutions of various strength were poured into the several autoclaves, which were then hermetically sealed, and placed in the steam space of a Babcock and Wilcox boiler, and left there for four months.

On removing and opening the autoclaves it was disappointing to find that the treatment had entirely removed the spring out of the samples, the least turn of the bolt nut allowing it to be slacked back entirely. The condition of maintaining the samples in a stressed condition had, therefore, not been fulfilled, and on testing the samples, by bending them, it was found that their ductility had not been impaired in the least. This experience was very disconcerting, and may account for the results obtained by Professors Heyn and Parr, who could detect no effect due to straining. The experience is, however, not without practical interest, as it points to a possibility that caustic liquor may cause a slacking back of rivets and caulked edges, and lead to leakages. The experience also reminded us that during the previous tests it had been noticed that the two rings (Fig. 2) which had not been exposed in the evaporator were firmly wedged together, whereas the exposed ones dropped apart quite easily. Evidently nearly all the spring had gone out of the metal.

The caustic liquor had, however, produced a very marked effect on the samples (Fig. 4). The samples as bent and exposed were too wide for the impact-testing machine, and had to be sawn in two. Much to our surprise the band saw would not look at them, and milling cutters, which were then used, had to be run at the very slowest speed, and even then broke their teeth, and yet the original bars could be cut quite easily at the highest speed.

It will be no easy matter to devise tests which will maintain the samples in a strained condition, for in our experiments the stress has to be produced by the elasticity of the material, and if that fails the stress disappears. The case is different in a boiler, for there the stress is due to the boiler pressure, and though the caustic may relieve some stresses, as is shown by the flying off of rivet heads, the average stresses will be maintained, and some local stresses may even be increased.

Professor Heyn has published nothing on this subject, but wrote that he could not confirm my results. Professor Parr, in the 94th Bulletin of the Illinois University, deals with the following points. He notes a change of electric potential if steel is immersed in caustic. The tensile tests showed a reduction of tenacity of about 30 per cent. after treatment, but this reduction was not influenced by change of density of the liquor. The elongation improved about 10 per cent. The samples which were stressed during exposure behaved in the same way.

Judging by our experiments and the description of Professor Parr's it is doubtful whether his samples were really stressed while exposed. He also submitted some of his exposed samples to alternate (fatigue) stresses, and found about 20 per cent. reduction in the number of reversals of stress before fracture occurred. (See later.) The impact test results were about 10 per cent. lower for the treated than for the untreated specimens.

Professor Parr's most important results are his determination of the hydrogen which is absorbed by steel and iron when immersed in caustic soda, and as it is well known that hydrogen makes certain steels very brittle, these determinations should explain the brittleness. However, as already stated, this brittleness seems to be produced only if the steel is stressed during exposure, but details of the conditions have not yet been determined. In our tests a change of density could not be detected.

The seriousness of the action of caustic soda will be evident from the following case :—

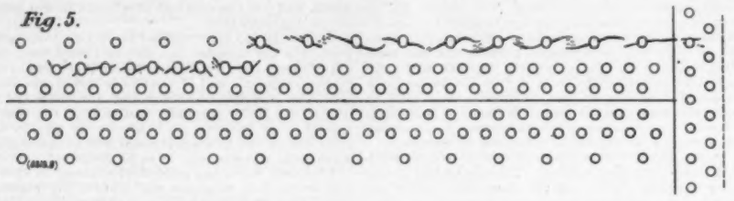
At the works of one of our members complaints were made to the manager that steam was escaping from one of the boiler shells to such an extent as to damage the goods in a drying loft above the boiler-house. A boiler-maker was sent for, who found some headless rivets in the butt strap of the third shell ring, and he was able to knock off a few more rivet heads. He renewed altogether nine successive rivets (in the outer or lowest row), and reported to the manager that he had noticed cracks in the shell plate between the butt straps. He suggested inserting additional rivets! Fortunately the works manager took a more serious view of the matter, and informed us. Our inspector removed a few more rivets and found more cracks, whereupon we asked that the butt straps should be removed, which was done.

The nature of the series of cracks was then revealed. (See Fig. 5 overleaf.) Close to the rivet holes the cracks gaped as much as ¼ in., and the region between two successive rivet holes seemed to be completely disintegrated, so much so that a few small pieces could be picked out. The surprising point about this case is that although the length of the crack was 5 ft. 6 in. (the boiler was built of four single-plated strakes 7 ft. 6 in. long), yet the friction of the butt straps prevented the shell plate from slipping out. The shell plates were $\frac{15}{16}$ in. thick, the butt straps ¾ in. thick, the rivet holes were ¾ in. diameter, and the pitches 2¼ in. lengthways and 2½ in., 2 in., 2½ in., 2 in., 2½ in. circumferentially.

The cause of the cracking of the plate could not be investigated for the following reason. I had been empowered to buy the whole or a part of the boiler, but difficulties were constantly raised by the owner, and as time was passing I offered to send a gang of men to the works who would cut out the fractured plate. Instead of assisting in the discovery of the cause the owner induced the builders of the boiler to buy it back. When we heard this we at once applied to them for some portion of the plate, but after some delay we were

informed that they were quite satisfied in their own minds as to the cause of the failure, and that they had in the meantime sold the boiler to a second-hand dealer. After some delay we received his name, and at once applied to him, but the answer was equally unsatisfactory. The only piece of information which was obtained from the boiler-makers was the name of the steel maker. These works have a well-established reputation, but seeing that our inspector had most carefully searched the plates without finding any brand, although the plates measured nearly 8 ft. by 25 ft., and as these boiler-makers had on previous occasions been using Continental basic steel, I do not attach much importance to this information.

Fig. 5.



Nevertheless, although the boiler-maker may have had reasons for objecting to a searching inquiry, it does not follow that the quality of the material was the only or the primary cause of the failure, which failure may have been due to the treatment which the boiler had received while in use. Until our suspicions were directed to the quality of the steel our impression had all along been that the crack was due to the introduction of caustic soda into the boiler, which admittedly had been the case, for the condensed steam from some caustic evaporators at these works was drained into the hotwell and was said to have been very alkaline on several occasions. As the make-up water was fairly pure, and the boilers were steamed for long periods at a time, the water in the boiler might easily become concentrated to a dangerous degree.

This view receives some confirmation from a paper by Dr. Wolff, of Holland, which was read at a recent meeting of the Iron and Steel Institute. His company (shipowners) seems to have had quite a crop of shell-plate failures. First one marine boiler exploded—this is almost a unique experience—then the shell plates of a sister-ship boiler were found to be cracked in a very similar manner to that of the present boiler, and then other boilers failed, but about these no details were given, though it was mentioned that some were built of acid steel.

Table III.—*Relative Fatigue Test Results expressed in Per Cent. of an Untreated Sample.*

Duration of Immersion. Days.	Temperatures during Immersion.		
	100 Deg. C.	180 Deg. C.	280 Deg. C.
	per cent.	per cent.	per cent
5	—	—	79
8	—	—	56
10	—	64	57
13	—	—	80
15	—	69, 82	75, 73, 79
16	—	—	77
17	85	—	—
19	—	82	—
23	—	88	—
24	—	90	—
30	110	—	—

Dr. Wolff seems to attribute these failures to the well-known irregular distribution of stresses in riveted joints, which are common, of course, to all marine boilers, of which there are probably 50,000 afloat and perfectly safe, but at the end of his paper he makes a very significant remark, based on Professor Mercia's experiments, and published in Professor Parr's paper (see above), which seem to suggest that the boilers in question had been dosed with soda for some considerable length of time. Professor Parr's paper contains the results of a number of experiments from which the information contained in Table III has been extracted. Samples of steel were immersed in solutions of caustic soda. One set was kept at a temperature of 100 deg. C. (212 deg. F.), another at 180 deg. C. (356 deg. F.), and the third at 280 deg. C. (536 deg. F.). Occasionally samples were withdrawn and tested, and the results compared with those of untreated samples. These results were all reduced to percentages of the original. The tenacity, elongation, &c., do not seem to have been affected, but, as will be seen from Table III, caustic soda seems to have had a marked effect on the fatigue properties of these samples, unless, as may well have happened, the standard untreated sample had by some accident appeared better than it really was. This is quite possible, for on the fifteenth day two samples were tested, and the results differed by 13 per cent.

It is doubtful whether Dr. Wolff is justified in drawing the conclusion that caustic soda causes at first a deterioration as regards fatigue and then an improvement, nor is he justified in judging the behaviour of boiler plates, which are subjected to static stresses, by fatigue test experiments. However, he says, "that as the boilers crack after having been in service for one or more years, recovery of the material from the effect of alkali, mentioned by the author, should have taken place long before the cracks started."

We have, therefore, his case and ours in which there is a strong suspicion, though no actual proof, that caustic soda in boilers leads to dangerous embrittlement of the plates. Carbonate of soda, as is well known, is gradually converted into caustic soda under high pressure boiler conditions. This change was, in fact, the cause of a number of boiler explosions in America which led to the committee being appointed on whose work Professor Parr based his report. But American boilers are built of basic steel which will occasionally crack even if not exposed to caustic soda, and the question still remains unsettled as to what was the cause of these several failures; was it the use of basic steel, or was it due to caustic soda?

CATALOGUES.

Electric Lighting Fittings.—The Sun Electrical Company, Limited, 120, Charing Cross-road, W.C. 2, send a catalogue of fittings for half-watt lamps, mainly reflectors and diffusers for direct and indirect lighting, specially suitable for industrial and commercial buildings. The practical information given is interesting and well illustrated, and all useful details of the fittings are clearly stated.

Electric Switches.—The British Thomson-Houston Company, Limited, Rugby, send catalogues describing their oil-break switches for controlling circuits up to 300 amperes at 3,300 volts, and another series for heavy alternating-current three-phase circuits up to 650 volts. These catalogues are fully illustrated and give all the practical information required as to dimensions, weights, fixing, special accessories, &c.

Duplicator.—The British Impactor, Limited, 166, Buchanan-street, Glasgow, send a circular describing their duplicator outfit for making up to 100 copies, in facsimile, of written or drawn papers. It is of the kind in which a composition is run into a tray and finished to a flat or concave surface, special paper and ink being required for the original. The system has still its own peculiar advantages.

Measuring Instruments.—A catalogue showing a fine series of precision measuring instruments and machines comes from the Société Genevoise D'Instruments de Physique, Geneva (London office, 87, Victoria-street, S.W. 1). Although most of the scales are metrical remarkably full attention is given to Whitworth screw threads, both bolt and gas pitches. The machines are adapted to measure the most minute errors in work-pieces or gauges. The catalogue is entirely in French.

Grain Elevator.—Messrs. Ford, Bacon and Davis, of New Orleans, New York and San Francisco, send a description of the grain elevator designed by them, and supervised in construction, for the port of New Orleans. It is a huge piece of work involving piling, building, and a great variety of machinery. Its purpose is to take the grain from trucks or boats, store, clean and blend it and deliver it again to ships in bulk or in sacks. The plant is well illustrated, though detailed description is lacking at present, of course for good reasons. It is a highly creditable piece of American work described with a modesty that is almost British.

Tool-Grinding Machines.—The Webster and Perks Tool Company, Springfield, Ohio, U.S.A., send a catalogue which shows that they have concentrated attention on the tool grinder with grinding wheels at either end of the spindle and central belt pulley drive. Some twenty types are illustrated and described, most of them being made in several sizes suitable for bench or independent standard support. Some are fitted for direct electric drive, the motor being totally enclosed in the standard. All conveniences and safety guards are well provided for. Buffing and polishing machines of the same general construction are shown; also a machine for grinding the edges of plates.

Electrical Gear.—Trailing cable sockets and plugs for oil-break gate end-boxes suitable for direct or alternating circuits up to 750 volts are the subject of a catalogue issued by Messrs. George Ellison, Perry Barr, Birmingham. The special purpose of this gear is to provide in one unit an oil circuit-breaker, interlock, and socket and plug for the trailing cables of coal cutters. These and other portable tools demand fairly large quantities of power, and require heavy trailing cables, and it is advisable, both for safety and economy, to fix thoroughly suitable connections at several intervals, rather than use very long trailing cables. The various patterns, dimensions, weights, methods of fixing and spare parts are precisely and fully stated.

Furnaces for Heat-Treatment.—Brayshay Furnaces and Tools, Limited, Mulberry-street, Hulme, Manchester send a leaflet showing four types of furnace. A regenerative furnace for annealing, requiring air at fan pressure only; a small furnace for the tool-room for treating high-speed tools; a natural-draught oven; a crucible furnace of the pit type. All except the crucible furnace stand clear of floor and walls, and all are properly sheathed against radiation and fitted with balanced doors and every convenience for working. The tool-room furnace is placed at such a height that a man may look into it. It is good to see these points attended to. The company has demonstration rooms at Manchester and Sheffield, and offers to carry out tests for any prospective customer who makes an appointment before calling.

Magnetos.—An interesting print, a pamphlet though in catalogue form, comes from the M–L Magneto Syndicate, Limited, Coventry, describing and illustrating works on a large scale specially for the manufacture of these little machines. Nearly all the work is small, requiring extreme accuracy, careful selection of material and rigid test of each completed machine. All these matters are appreciated by the company and are satisfactorily dealt with in the letterpress. It is evident that only large and specially trained staffs of workers and managers will be able to produce this machine correctly on anything like economical lines. There is hardly any piece of mechanism in which reliability is so important, especially as it is so unamenable to the efforts of the unskilled repairer. This pamphlet indicates that British manufacturers realise that they must not only meet the war emergency, but establish a reputation as inviolable as if there were no war pressure.

Horizontal Drilling Machines.—In dealing with large work-pieces in which a number of holes have to be drilled there is a great advantage in being able to set the piece on a level table and move a horizontal drill from place to place, on the surface presented, as required. This method is provided for in a series of large machines made by Messrs. G. and A. Harvey, Limited, Govan, Glasgow. The whole drilling mechanism is movable horizontally on a low baseplate and vertically on the movable standard, in both cases on planed surfaces with screw-and-rack gear operated by hand wheels. The smallest machine has vertical and horizontal traverses of 30-in., feed traverse 15 in., spindle 2 in. diameter, and 16 drill speeds ranging from 41 r.p.m. to 480 r.p.m. The largest machine has a 10-in. diameter spindle, 48 drilling speeds, will drill holes to a depth of 5 ft. 3 in., centre of the drill movable 12 ft. 3 in. horizontally and 9 ft. 3 in. vertically; the bed surface for the work-piece being about 19 ft. by 7 ft., and the total weight about 55 tons. Twelve sizes are shown in the catalogue, several having two drilling standards which may be operated separately. These are examples of the monster machine tools now being made. All the details are carefully worked out to produce accurate work and give every convenience and ease in handling. Tapping, stud-inserting and milling are provided for also.

Air Compressors.—The rapidly extending use of compressed air at medium and fairly high pressures is proved in a striking way by a catalogue received from Messrs. Robey and Co., Limited, of Lincoln. It shows about ten different types of compressor, with eight to sixteen standard sizes of each type. In addition to several belt-driven machines, which are also fitted for direct drive by an electric motor, there are standard compressors with electric motors for taking in 1,000 cub. ft. to 8,000 cub. ft. of air per minute, and compressing it to 80 lb. or 100 lb. per square inch in two stages of pumping. In all these sizes the brake horse-power at the compressor shaft required to compress 1,000 ft. per minute from atmospheric to 80 lb. pressure is 170, and to 100 lb. pressure 190. Most of this work, however, is done by steam engines with the compressor piston rod coupled direct in line to the tail of the engine piston rod. In one type of this kind there are 16 standard sizes, for taking in volumes of 500 ft. to 8,000 ft. per minute. The steam and air pressures are respectively 130 lb. and 80 lb., but these are altered to suit any requirements. Several types of steam engine are used, vertical and horizontal, chiefly to meet requirements as to pressure and capital cost. The large plant is made with coupled tandem compound condensing engines with drop valves, to run night and day for long periods. A small steam plant with slide-valve engine, 6½-in. cylinder, working at 100 lb. steam pressure, takes in 42 cub. ft. of air per minute and compresses it to 80 lb. Good valves are the dominant factor in both engines and compressors, and on these the catalogue is very instructive. There are also several tables of data and much information about compressed air which will be useful.

Inferior Lignite as Boiler Fuel.—The use of lignite high in ashes having caused considerable difficulties, Dr. Loschge investigated the problem at the Technical High School of Munich, making his experiments on a Babcock water-tube boiler provided with a mechanical stoker (*Zeitschrift Verein Deutsche Ingenieure*, September 1 and 22, 1917). The lignite had to be powdered to maintain a steady fire, and at the same time had to be fed wet, lest it be blown away. The ashes fused and produced a hard clinker, which had to be broken up; for this purpose the grate had to advance at a fairly rapid rate, which made the fire unsteady. Straight bars were fixed to the hopper, or curved, heavy bars were pivoted in the hopper, to draw longitudinal furrows in the fuel lying on the grate. It was also found advisable to separate the furnace space as much as possible from the big flue carrying the hot gases up to the tubes of the boiler; the roof of the furnace was so arched as to send the heat radiated from the grate back to the grate; thus a hot fire was kept, but there was no direct heating of the tubes by the flames, and the hot gases did not travel vertically upward.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

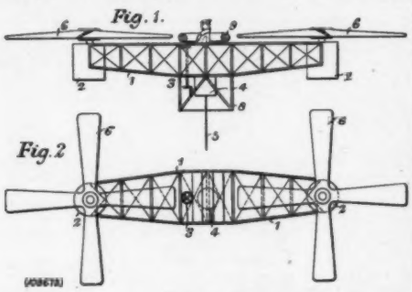
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AERONAUTICS.

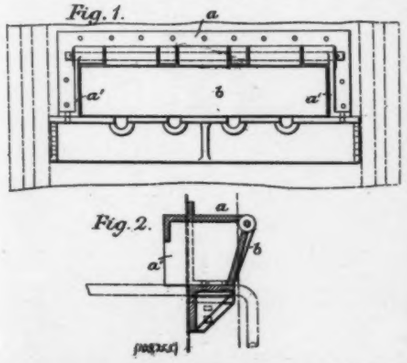
109,672. P. J. Pybus and The Phœnix Dynamo Manufacturing Company, Limited, Bradford, Yorkshire. Aircraft. (2 *Figs.*) September 30, 1916.—The present invention is concerned more especially with heavier-than air machines for observation purposes of the kind in which the machine is provided with lifting helicopters driven by an electric motor supplied with power through a cable from the ground level. According to the present invention, a separate motor is employed for each helicopter supplied from the ground level, and owing to the necessity for lightness a high-speed electric motor is directly coupled to each helicopter. A single cable can be used for securing the machine and for supplying the electrical energy to the driving motor or motors from the source of supply on the ground or on board ship. The framework of the machine 1



supports at either end the stator 2 of a squirrel-cage induction motor. The controller handle is shown at 3, and the regulating resistance at 4. The cable 5 which secures the machine to the ground also serves for the supply of current to the motors. Each of the motors drives one of the helicopters 6, which are respectively of left and right-handed pitch. The observer has his post at the centre of the machine immediately above the resistances 4, and a stand 8 is shown for supporting the device when at rest on the ground. Obviously such a machine is wholly dependent upon the supply of power to the motors 2 and helicopters 6, and if that power failed the machine would quickly fall. In case of such accident, in order to save the observer's life he is provided with a parachute 9. (*Accepted October* 3, 1917.)

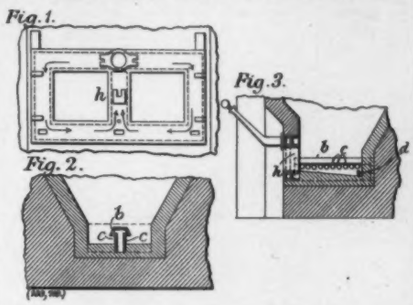
GAS ENGINES, PRODUCERS, HOLDERS, &c.

109,755. Dowson and Mason Gas Plant Company, Limited, T. Wright and E. W. Mawby, Levenshulme, Manchester. Gas-heated Annealing Furnaces. (7 *Figs.*) May 4, 1917.—These improvements refer to the doors of gas-heated annealing furnaces, and in particular those of continuous shell billet, gas-heated annealing furnaces. The supporting frame *a* of the door is extended forwardly, and the door *b* is pivoted to the forward edge of the frame. At each end of the



door the frame is provided with side cheeks a_1, whereby all draught or ingress of cold air (or egress of hot air) at such points when the door is opened, is prevented. The door, which when closed occupies the inclined position shown with its lower edge to the rear of the hinge, is opened automatically by the shell billets being pushed against the door, the door closing automatically immediately the last billet has been pushed fully into the furnace. (*Accepted October* 3, 1917.)

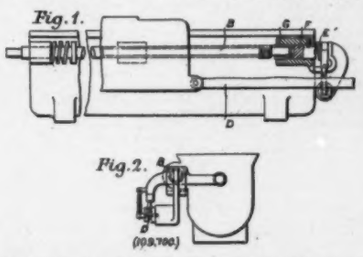
109,710. Kilner Brothers, Limited, and F. W. Knowles, Dewsbury, Yorkshire. Gas Producers. (4 *Figs.*) December 11, 1916.—This invention relates to furnaces for the production of combustible gas wherein steam is introduced through the furnace-door frame into a perforated steam box under the fire. According to this invention, at the front of the furnace is provided a rectangular framework comprising two horizontal and three vertical members, all the members being hollow or tubular, and their ducts or passages being in communication with each other in such manner that steam introduced centrally from the outside of the setting divides into two streams which travel all round the periphery of the framework and reunite in the central vertical member A, whence the steam is delivered at the inside of the setting to a steam-box *b*. This framework is fixed on the front of the furnace and provided with hinges and latch members for the reception of a pair of doors and their fastening devices. The steam-box extends to the back of the fireplace



and has perforations *c* on each side for almost the entire depth of the fireplace from front to back, that is, the last perforation is close to the back wall. Outside this steam-box, on each side, is a sloping floor, the slope falling from front to back, the floor being composed, for example, of puddled clay paved with brick; and near the end of the steam-box below the perforations is a slot or opening *d*. The surplus condensation water from the steam is thus drained to the bottom of the producer and passes through the opening to the bottom of the steam-box, thus keeping the steam-box cool. (*Accepted October* 3, 1917.)

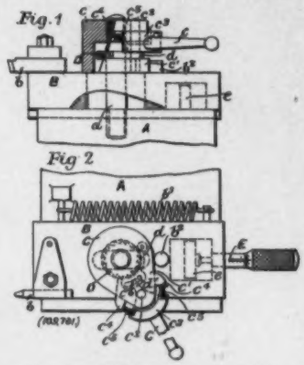
MACHINE AND OTHER TOOLS, SHAFTING, &c.

109,700. A. Drummond, Guildford, Surrey. Lathes. (6 *Figs.*) November 25, 1916.—This invention relates to lathes of the type in which inaccuracies of the lead screw are compensated for by automatic adjustments controlled by a cam-plate or correcting member cut in accordance with careful measurements of the tool movement for all parts of the screw, the outline of the cam surface representing on a greatly enlarged scale the irregularities in or associated with the lead screw, which cause uneven tool movement, so that a compensating action corresponding to all such irregularities can be introduced into the lathe mechanism. According to this invention, the required corrections are applied to the lead screw B by axial movements of the screw, effected by the aid of a wedge member E having a small angle of slope and controlled by the cam-plate D, which moves with the tool. In one construction embodying this



invention, the lead screw bearing F is made in the form of an accurately-ground socket adapted to slide in a closely-fitting bearing member or sleeve G, the reduced bearing end of the screw entering the socket and meeting at its end a central thrust ball through which the axial correcting movements are transmitted. The lead screw B may be spring-pressed against the ball. The end of the sliding bearing may also be provided with a thrust ball meeting the face of the correcting wedge E, the wedge being mounted upon a lever arm pivoted at one end upon a knife-edge bearing or an accurately-fitted axle, and at the other end meeting the cam-plate. The cam-plate D is conveniently fixed to the saddle of the lathe so as to move with the tool, and as the plate travels it turns the wedge arm through a greater or smaller angle according to the amount of correcting movement required for the various portions of the lead screw. (*Accepted October* 3, 1917.)

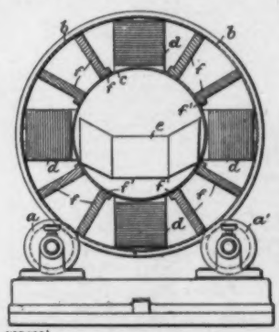
109,701. A. Drummond, Guildford, Surrey. Tool Slides. (4 *Figs.*) November 25, 1916.—This invention relates to the tool slides of lathes of the type adapted for very accurate work in which the cross-slide is clamped or locked in position after each adjustment for successive cuts. According to this invention, the locking bolt *a* of the cross-slide is provided with a locking arm or lever C adapted, when turned in one direction, first to release the slide and, on further movement, to withdraw it from working position and to hold it in withdrawn position, and, when turned in the opposite direction, first to allow the slide to move to working position, and on further movement again to lock the slide. The slide B is provided with a small fixed ratchet D, with which engages a pawl carried by the nut *c*. The locking arm C is not made in one with the nut *c*, but is pivoted to it at c^2, and is provided with a quadrant member c^3 moving between the stop c^4 on the nut, springs being interposed between the stops and the ends of the quadrant. The arm is thus free to turn through a limited angle in either direction without turning the nut. The end of the arm carries a pin c^5, which projects into the slot d^1 of the pawl *d*, and movement of the lever relatively to the nut causes the pawl to be withdrawn from the fixed ratchet disc D so that the nut is free to turn. The operation of the device is as follows: At the end of a cut the locking arm C is turned in the release direction, the first part of the movement withdrawing the pawl from the ratchet D. Continued movement acting through one of the stops c^4, turns the nut *c* and releases the cross-slide from the clamping pressure of the nut, the cam projection c^1 then meeting the pin b^2. The locking arm, nut and pawl now move together, and the cross-slide B is pressed back through the pin b^2 against the pull of the spring b^3, until the tool *b* is clear of the work. Immediately the arm C is released, the spring c^5 causes it to spring back to its central position relatively to the stops c^4, and cause the pawl to engage the ratchet D and to hold the whole device in its withdrawn position. After movement of the cross-slide B to its new position for the next cut the arm C is turned in the opposite direction, the initial movement again withdrawing the pawl from the ratchet D, so that the nut *c* is left free to turn on the bolt *a*, when the locking arm acts through the forward stop c^4 and turns the nut *c*. Continued movement allows the pin b^2 of the cross-slide B to travel



forward with the slide under the action of the spring b^3, until the tool *b* is in cutting position, the nut *c* screwing down on the bolt *a* until, after the slide is in position, the nut binds tightly upon it and clamps it to the saddle A. While the slide is held in withdrawn position the usual micrometer adjustment is made by means of the micrometer E, the end of which meets the anvil *e* carried by the main slide A, and so limits the forward position of the slide B. (*Accepted October* 3, 1917.)

MINING, METALLURGY AND METAL WORKING.

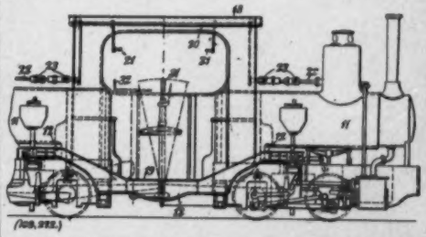
109,766. The Hardy Patent Pick Company, Limited, and G. J. McD. Smith, Sheffield. Magnetic Separators. (1 *Fig.*) June 4, 1917.—This invention relates to magnetic separators of the rotary type, and consists in an improved construction and arrangement of the electro-magnets employed. Motion is imparted to either of the wheels *a*, a^1, which, in turn, are in frictional engagement with the rim of the cylinder casing *b*, which is thereby rotated. Between the interior barrel *c* and the casing *b*, are placed any desired number of electro-magnets *d*. These magnets are separately excited, and cause any magnetic metallic fragments in the material being treated, which is charged into the barrel *c*, to cling to the walls of said barrel and to be carried round with it in its rotation. As each magnet in turn reaches the highest point in the revolution, the current thereto



is automatically cut-off, whereupon those metal fragments which are attracted and held by such magnet are released, and fall by gravity on to a shoot *e*. According to this invention, there is inserted on either side of each magnet *d*, a magnetisable metallic arm or strut *f*, making contact with both the barrel *c* and the casing *b*. These struts *f* are magnetised through the medium of the casing *b*, by the magnet to which they are adjacent, and naturally have an opposite polarity to such magnet. It will be observed that the struts *f* are made with enlarged inner extremities f^1 which, in conjunction with the face of the electro-magnet, provide a magnetic field of greatly increased area and intensity. Also, the presence of these struts prevents an electro-magnet from which the current has been cut off from being influenced by adjacent energised magnets. (*Accepted October* 3, 1917.)

RAILWAYS AND TRAMWAYS.

109,272. Robert Stephenson and Co. (1914), Limited, and C. N. Goodall, Darlington (Durham). Locomotives. (6 *Figs.*) June 2, 1916.—This invention relates to articulated



locomotives of the kind wherein two engines are coupled together by means of a frame which, at or near its extremities, connects with each engine at or near the centre of its wheel base by means of ball and socket or other flexible joints, and upon which frame

the driver's platform and cab common to the two engines are mounted. According to the present invention, the applicants provide a duplex articulated locomotive of this kind with means whereby the two power units are controlled by one set of levers, handles or the like situated in the cab which forms part of the independent platform connecting the two power units together, the said set of levers, handles or the like being connected by flexible attachments to the parts to be controlled of each power unit. 11, 11 are the two self-contained locomotives, and 12 is the independent frame or platform connected to each locomotive at its extremities. The frame is preferably of the form shown, the central portion forming the base for supporting the cab 18 and control platform 19. The means for controlling the regulator of each locomotive consists of a shaft 20 extending longitudinally, and on which is mounted one or more handles 21. The regulator of each locomotive is connected to the handles 21 by means of a shaft 22, universal joints 23 and link 25. The reversing gear of both engines may be connected to and operated from a single reversing handle 31 or apparatus such as a screw or steam gear, and the brake gear may be similarly controlled from a wheel 32. (*Accepted September* 19, 1917.)

109,677. C. J. Bagley, McN. Cornforth, and the South Durham Steel and Iron Company, Limited, Stockton-on-Tees. Brakes. (5 *Figs.*) October 7, 1916.—This invention relates to brakes for railway wagons of the kind in which the brake blocks are disposed so as to act upon the top or upper part of the wheel, and are operated in such a manner that when the brakes are applied the blocks are forced in between the top or upper part of the wheel and the underframe or body of the vehicle, and the weight of the vehicle or the vehicle and its load is utilised in increasing the brake power. According to the present invention, the brake blocks 5 are preferably formed or provided on the back or side adjacent to the underframe T, with three inclined or wedging faces or bevels *a*, *b*, *c*, serving to permit the brake blocks to accommodate themselves to the weight of the wagon and enable the weight to bear effectively on the wheels through the brake blocks, when the wagon is empty, half or partially, or fully loaded, one of the wedging faces *a* taking effect when the wagon is empty, the second *b*

Fig. 1.

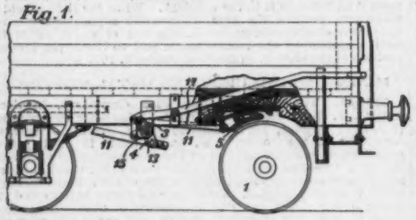


Fig. 2.

when the wagon is partly loaded, and the third *c* when the wagon is fully loaded, according as the wagon body descends on its springs under the load. In one construction in accordance with the invention, a brake block of cast-iron or other material is provided for each wheel on one side of the wagon, these brake blocks being each formed or provided with three wedging faces or bevels as mentioned, and being suspended by a hanger or hangers pivoted at one end to the undercarriage and connected to the brake block by a pin-and-slot connection. The two blocks on the side referred to of the wagon are operated by push rods 11, connecting to rocking arms 3, 4, for example, the arms of a tumbler, mounted on a cross-shaft 13 below the undercarriage. A crank 15 is fixed at each end of the tumbler shaft, each crank being connected by a link to a brake lever 17 at the corresponding side of the wagon. The two brake levers are pivoted to the outside of the wagon by gudgeon-pins conveniently fixed to the sole or underframe of the wagon. By depressing either of the brake levers the cranks are raised, and the tumbler rotated to cause the push rods 11 at the side where the brake blocks are situated to force the brake blocks 5 in simultaneously between the underframe and the tops of the wheels 1. (*Accepted October* 3, 1917.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

108,799. The Quasi-Arc Company, Limited, and W. L. Cole, Westminster, London. Boiler Stays. (1 *Fig.*) December 19, 1916.—This invention relates to stays used for staying flat surfaces of boiler plates forming water or steam spaces. According to this invention, stays are secured at their ends by electric welding in chamfered holes in the plates. Stay rods of a rather larger diameter than has been usual hitherto can be employed if desired, so that the pitch or distance between the adjacent stays can be increased, and the cost of construction can be correspondingly reduced, while maintaining at least the legal standard of strength to resist pressure. In carrying out the invention, stay rods are used such as that shown at *a*, the ends of which will just pass through plain holes in the plates *b* and *c*, and will lie flush with the outer faces of the plates. The

holes in the plates are outwardly chamfered, and when the stay rods are inserted the chamfered grooves around the ends of the rods are filled in with a deposit of welding metal as at *d*. This is preferably effected by electric welding with the use of electrodes covered with a slag forming layer of blue asbestos yarn, the electrodes being worked according to the Quasi-Arc process; according to this process the ends of the electrodes are held close to the work, so that it is a sputtering or quasi-arc which passes. When the joints are formed in the manner described, the ends of the stay rods are welded to the plate by a collar of deposited metal *d* of expanding diameter, so that it is impossible for the stay rods to be pulled out by pressure on the plate. The full diameter of the rods is available to withstand stresses, and no threading of the rods or tapping of the holes in the plates is required. (*Sealed.*)

TEXTILE MACHINERY.

108,802. The Fine Cotton Spinners and Doublers' Association, Limited, and A. Bardsley, Manchester. Loop-Banding Machines. (6 *Figs.*) December 27, 1916.—This invention relates to machines for making cotton driving bands for the spindles of doubling frames, known as loop-banding machines, and in the spindles therefor. The spindles A and A^1 are mounted in the frame of the machine in the ordinary way, the spindles A^1 being of the ordinary construction and capable of movement to and from the spindles A. Each spindle A is constructed at its free end with a fixed collar washer B, and behind this is a sliding sleeve C pressed against the fixed washer by a spring encircling the spindle and bearing against a fixed collar or shoulder on the spindle. The washer B is notched, toothed or serrated around the periphery to more securely grip the yarn, the notches preventing the yarn slipping when the spindle is revolving, and the sliding sleeve forced against it by the spring forms a clamp between which the free ends of the yarn are secured. A number of forked levers D—one for each spindle A—is mounted loosely on a shaft E, the end of each lever engaging the sleeve C of the spindle, by which it is drawn back

Fig. 1.

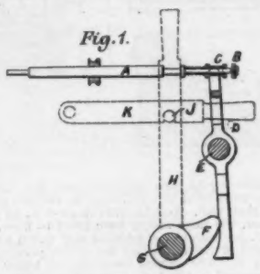
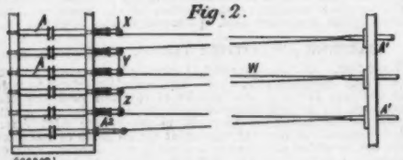


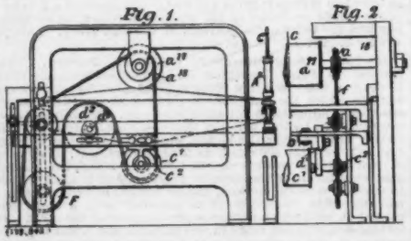
Fig. 2.



to release the yarn when finished and to insert a fresh length. The forked levers D may be operated singly by hand or collectively by a series of cams F on a camshaft G. The shafts E and G are mounted in suitable bearings on the beam or rail of the machine, and the cams are actuated by a hand lever H fitted to one end of the shaft G. A latch lever K is pivoted to one side of the lever H and is provided with a notch to drop over the pin J when the camshaft is moved to hold the cams F out of contact with the forked levers D. In operation, the sleeves C on the spindles A are held open by the cams F and levers D, and the yarn W is placed in the machine in the ordinary zigzag fashion, the yarn being knotted at one end to the hook of a spindle A^2 and then passed backwards and forwards over the hooks of the spindles A^1 and the notched washers B of the spindles A. The sliding sleeves C are then closed upon the yarn to secure it to the spindles A. When the yarn has thus been fixed, the yarn is severed at the points X, Y and Z, and the operation of twisting carried out. When the looped bands are finished, the sliding sleeves C are again pushed back by the levers D and cams F to release the finished bands and to receive a fresh length of yarn. (*Sealed.*)

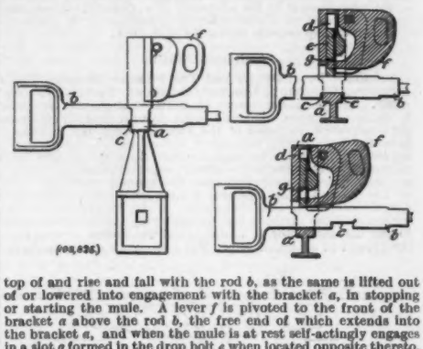
108,842. Renshaw and Fallows, Limited, and J. H. Fallows, Blackburn, Lancashire. Spinning, Doubling and Twisting Machines. (2 *Figs.*) July 13, 1916.—This invention relates to spinning, doubling and twisting yarns and threads and to that type of apparatus in which a ring and traveller are mounted upon, or carried by, a tube or cylinder that is rotatably mounted on a stationary sleeve through which the spindle passes, the tube and cylinder being driven by flexible connections from two separate cylinders, one of which can rise and fall. According to this invention, the drive is transmitted to the spindles by a flexible connection passing from a pulley on the cylinder which drives the carriers to a pulley on the cylinder which rises and falls with the lifter rails, over another pulley which rises and falls with such cylinder, under a pulley on a stationary stud, and back to the pulley on the cylinder which drives the carriers. A^2 indicates one of the carriers and C one of

Fig. 1. *Fig. 2*



the spindles. The spindles C and carriers A^2 may be driven by bands from cylinders c^1, a^{17}, and, in the arrangement shown, a chain wheel a^{18} is rigidly connected with the cylinder a^{17}, and a chain wheel c^2 is rigidly connected with the cylinder c^1. The cylinder c^1 is carried at each end by a bearing on a cross-frame d^1, which connects the lifter rails D, and supported in a bearing d^2 on one cross-frame above the chain wheel c^2 and to one side thereof is another chain wheel d^3. Mounted below and to one side of this wheel, on a stud, which may be attached to some stationary part of the frame, is another chain wheel F. Passing around these chain wheels is an endless chain *f*, which passes from the top cylinder chain wheel a^{18} to the bottom cylinder chain wheel c^2, under the latter, over the chain wheel d^3, that rises and falls therewith, then under the wheel F on the stationary stud, and back to the upper cylinder chain wheel a^{18}. By this arrangement, during the lifting and lowering of the two chain wheels d^3, c^2, on the lifter rail frame d^1, one wheel gives off what the other wheel takes up, and an even tension is maintained upon the chain during all positions of the bottom driving cylinder c^1. (*Accepted August* 29, 1917.)

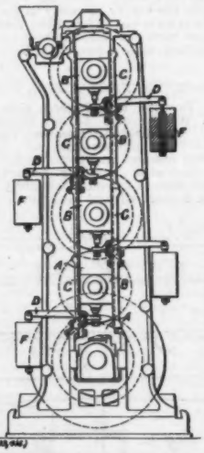
108,836. J. Dransfield, Hollinwood, Oldham, Lancashire. Self-Acting Mules. (5 *Figs.*) May 11, 1917.—This invention relates to devices for self-actingly locking the starting and stopping rods of self-acting mules in the required position or positions. The invention consists in providing the bracket in which the rod is rendered slidable, and which rod is generally provided with one or two recesses adapted to engage the said bracket, with a drop bolt and a locking lever in operative connection therewith, which bolt is adapted to abut against the rod and the lever to self-actingly lock in position the bolt, and thereby the rod, in the bracket, when one of the said recesses has engaged the bracket, after the machine has been either stopped or started. *a* is the bracket, *b* the starting and stopping rod slidable therein, and on the bottom, as usual, provided with a recess *c*. Above the rod *b* the bracket *a* is formed with a cavity *d*, in which a drop bolt *e* is employed, adapted to rest upon the



top of and rise and fall with the rod *b*, as the same is lifted out of or lowered into engagement with the bracket *a*, in stopping or starting the mule. A lever *f* is pivoted to the front of the bracket *a* above the rod *b*, the free end of which extends into the bracket *a*, and when the mule is at rest self-actingly engages in a slot *g* formed in the drop bolt *e* when located opposite thereto, as shown in the upper right hand figure of the drawings, thereby locking the drop bolt *e* to the rod *b* and the rod to the bracket *a*. In order to permit of unlocking the rod *b* when it is required to start the mule, the locking lever *f* is withdrawn by hand, and thereby the bolt *e* released so as to permit of the rod *b* being lifted and thereby disengaged from the bracket *a* and longitudinally displaced, as shown in the lower right hand figure of the drawings. In the latter position, the plain part of the bottom of the rod *b* rests upon the bracket *a*, the free end of the locking lever *f* is located opposite the lower or blank part of the bolt *b*, and lever *f* thereby kept in its inoperative position. (*Sealed.*)

MISCELLANEOUS.

109,416. F. C. Bettison, and Greenwood and Batley, Limited, Leeds, Yorkshire. Roller Mills. (1 *Fig.*) May 30, 1917.—This invention relates to roller mills such as are employed for crushing oil seeds and similar materials. In this invention, the bearing blocks B at the ends of the crushing rolls A, which are free to move in a vertical direction only, are acted upon by the short ends of levers D, the fulcrums of which are attached to roll-housings C; the long ends of the levers carry suitable weights F, or, alternatively, springs, one end of which is fixed to the housing with suitable provision for adjusting the tension



or compression. By suitably proportioning the levers and weights, or springs, the weight of any or every crushing roll can be counterbalanced to any desired extent. The effect is exactly as though lighter rolls had been substituted for the heavier ones, and as each roll still rests on the one below it, there is no difficulty with the driving, and any variation in the feed does not alter the pressure on the material, the rolls rising or falling as the feed increases or decreases, with consequent uniformity in the work done on the material being crushed. (*Accepted September* 19, 1917.)

"Borrodising."—"Borrodising," says *Canadian Machinery*, is the name given to a system of electro-deposition of zinc which has been introduced as a preventive against corrosion of the steel fittings of aeroplanes and seaplanes. It is a method of cold electro-galvanising carried out in such a way that the zinc so unites with the underlying metal that only by extreme wear can the surface of steel be exposed. As the metal is not subjected to the usual pickling bath prior to the galvanising, it is claimed that there is no reduction in the strength of the metal after treatment.